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EDISON LIGHTS IN AMERICA.

A LITTLE more than a year ago the two chief corporations owning Edison electric light patents in the States—the Edison Electric Light Company and the Edison Company for Isolated Lighting—resolved to consolidate their forces and work the whole field, so far as it was open to them, in combination. The amalgamation took effect from December 31st, 1886, and the new Edison Electric Light Company came into being with the year 1887. Twelve months have passed, and now we have before us the first annual report of the board of trustees. This report presents many features which it is interesting, and may be instructive, to consider. At the outset, the consolidation itself is a proof that the trustees have discovered how mistaken was the policy so persistently followed, not in America only, but upon this side of the Atlantic likewise, by greedy promoters and their enthusiastic, fatuous dupes in the early days of electric lighting. Nought would satisfy these but to grant concessions, for which payment was made in cash and shares, for the lighting of specified sections of the country by subsidiary companies, and as long as there was a rood of land the right to light which by their own particular system they had not sold, they were not satisfied that they had done all that it was possible to do to make the parent company a remunerative concern. The consequence of this course was that large sums were paid into the coffers of the promoting company; the individual promoters reaped golden harvests—then they retired from the scene. It was soon discovered that the sale of patent rights could not go on for ever, and that something more of the nature of legitimate business must be done if dividends were to be maintained. But business was not easy to get; the sales of concessions had placed limits upon the scope of the parent company, and each subsidiary found it equally difficult to get work to do in its own district.

In so far as these remarks apply to England, our readers will recollect how shareholders came to the conclusion that they had paid enormously extravagant sums for patents of doubtful value, how their bitter disappointment bred angry accusations against innocent but unfortunate directors, and how in the sequel they all consented to become re-absorbed by the parent. This may not be a faithful representation of the course of events in the United States, but we have it plainly indicated in the report before us that some thing of a parallel nature must have there taken place. "While at the inception of electric lighting," runs the report, "the plan of parting with patent rights for large blocks of territory had its attractions, actual experience has shown that it is productive of unsatisfactory results, and oftentimes of serious embarrassment." However, as a result of the important amalgamations which have taken place, the present Edison Electric Light Company now (with very few exceptions) possesses undivided control of the Edison patents throughout North and South America.

Whether it is a further consequence of the amalgamation or not we do not know, but it is a fact which we are glad to note that the past year has been by far the most prosperous one in the history of the Edison Company. Thirteen new companies under its immediate control have been organised since January 1st, 1887, with a total of 67,500 lamps. Of the older companies the capacity of 13 has been increased to the extent of 37,200 lamps, the total capacity now being 59,500 lamps.

The basis upon which the local Edison Companies have been formed is evidently a sound and an equitable one, for in nearly every case substantial and growing dividends varying from 6 per cent. to 14 per cent. have been paid. Where the older English companies erred was in selling outright their patents for the districts covered, retaining no means of control save that afforded them by possession of the shares which formed part of the purchase consideration. The American Edison Company utilises the local companies as agents, they all act upon a uniform basis, and are under immediate control. There are 121 of these local companies, and they use altogether 323,080 lamps.

The trustees complain, rather unduly, of the keenness of the competition they encounter. It is not a very dignified proceeding for a large company like this to "regret that competition has continued unabated." Of course we can all understand and sympathise with its desire for a complete monopoly; but seeing that there are antagonists in the field, it is far better even from the commercial point of view, to meet them in brave and generous rivalry, than to whine that they have no business there. It cannot be said, however, that the Edison Company has suffered much from, or compared unfavourably with, the other companies which have sought to emulate its successful career; and probably the "regret" is more a growl than a whine.

As we have already learnt, Mr. Edison claims some share in the development of converter systems; indeed according to his company's report, "All that is good in any such system is to-day broadly covered by Mr. Edison's earlier patents and patent applications." Nevertheless the company has thought fit to purchase the Zipernowsky-Deri patents, and they say the only "invention" they do not control is "the alternating current," "a device which, from a commercial standpoint, has no merit in itself, and, being of high pressure, is notoriously destructive of both life and property." An alternating current station has been installed to compete with the large Edison central station in New Orleans, but the Edison people profess to dread its competition not at all. A report upon the new venture has been drawn up by the superintendent of the Edison station, and from it we elicit that for the best alternating machine an efficiency of only 85 per cent.

is claimed. The converters, when working at their nominal capacity, a condition attainable during two hours only in every twenty-four, have an efficiency of 95 per cent.; on a light load the efficiency falls to as low as 37 per cent. "Then again," says the Edison superintendent of his rivals, "they cannot run the generators in unison in the same circuit, except under very exceptional circumstances. The local electrician has been trying for months to get his machines to work together, but has not succeeded so far."

The Company's counsel are pretty fully occupied with litigation. Suits have been instituted against "the most notorious infringer of our central station patents," and others, and the lamp patent contests are still going on. It is expected that some definite results will be reached within the current year.

Of general interest will be the statement that among the patents issued to the company during the year that has passed is one which has been the subject of a prolonged contest in the Patent Office for over seven years. This patent is said to cover, in the broadest way, not only all the fundamental principles of a complete system of distribution, but many other incidental principles such as the indication and regulation of pressure, and the measurement of the current consumed by the user. "So comprehensive, indeed, is this patent," say the trustees, "that (quite apart from the many other central station patents we already possess) it may be fairly defined as broadly covering 'the sub-division of the electric current,' and as awarding to the Edison Company the exclusive control of the generation and distribution from a central station of electrical energy for whatsoever purposes it may be applied by the user." So it seems that in America at all events Edison is to have things pretty much his own way in central station lighting. Whilst we are glad to chronicle the commerical success of the Edison Company, we cannot say that we view with pleasure or satisfaction this handing over of absolute rights to one man, who, however valuable may have been his works and discoveries, has certainly no claim to the whole realm of electrical invention.

PROF. EDWIN J. HOUSTON thinks that the numerous ingenious applications that have recently been made of heat of electric origin may render a brief reference to the early applications of electric heat to a few furnace operations not without general interest, and he therefore proposes giving in successive issues of the *Franklin Institute Journal* a brief notice of a few of the more interesting of these earlier electric furnaces. At a meeting of the Royal Society of London, held on June 15th, 1815, J. G. Children, F.R.S., gave an account of an interesting experiment in which Mr. Pepys established the now well-known identity of chemical composition of the diamond and ordinary carbon. Pepys's demonstration of this identity was founded on the fact that a diamond, heated in contact with pure iron, under circumstances where admixture with foreign matters was prevented, converted the iron into steel. It occurred to Mr. Pepys that the battery would afford an *experimentum crucis* on the subject: and his ingenuity readily suggested a mode of making it. He bent a wire of pure soft iron, so as to form an angle in the middle, in which part he divided it longitudinally, by a fine saw. In the opening so formed, he placed diamond powder, securing it in its situation by two finer wires, laid above and below it, and kept from shifting by another small wire bound firmly and closely around them. All the wires were of pure, soft iron, and the part containing the diamond powder, was enveloped by thin leaves of talc. Thus arranged, the apparatus was placed in the electrical circuit, where it soon became red-hot, and was kept so for six minutes. The ignition was so far from intense, that few who witnessed the experiment, expected any decided result. On opening the wire, however, Mr. Pepys found that the whole of the diamond had disappeared: the interior surface of the iron had fused into numerous cavities, notwithstanding the very moderate heat to which it had been exposed; and all that part which had been in contact with the diamond was converted into perfect blistered steel—a portion of it being heated red and plunged into water became so hard as to resist the file and to scratch glass." Prof. Houston thinks the above is an excellent description of an electric furnace pure and simple. Bearing in mind the date of the publication it shows very considerable ingenuity.

ONE of the nominal promoters of electric lighting companies during the 1883 *furore* was Mr. J. Hammond, well-known to the public in connection with "The Hammond Electric Lighting Company." This gentleman has associated himself with a new venture, which is expected to be shortly introduced to the public under the title of "The House-to-House Electric Lighting Company," the capital to be raised being, we understand, £350,000. There is now a great revival of interest in central station electric lighting, several promising schemes controlled by competent engineers being on foot with every probability of success. We hope that during the next 12 months public confidence, which a few years since was so rudely dispelled, will be restored, but it would be a matter for regret if any attempt to revive the former speculative mania, now, we trust, a thing of the past, should be encouraged, and this, suggests a friend whose heart and soul are devoted to electric lighting, does not appear altogether unlikely if the above company is successfully floated. Any group of gentlemen, says our friend, who want to form themselves into a small central station syndicate can now do so, and there are several respectable firms always ready to take up a contract and guarantee the work. These small ventures, which involve a capital of some £10,000 in each case, can be started without any speculation and without any appeal to the public, simply by the householders combining themselves together.

FROM a perusal of the advertisement of the "House to House Electric Lighting Company," it appears on the face of it that the operations therein set forth are all in favour of the consumer, and that no capital is asked for. But there is another construction to be placed upon it. It will be noticed that 50 householders, together necessitating a total of 2,000 lamps, must be collected in order to start a central station. Supposing a charge of £5 per lamp per annum is levied, and we expect this will not be far from the mark, although it is, of course, possible that a lower figure would enable the company to work at a profit; the sum total amounts to £10,000, just the figure quoted by our interviewer. So, after all, it is possible that the consumer will have to find in some way or another the capital of the company. We

shall be glad to learn if the opinions of others correspond with those here expressed, for we are not by any means sure that we have given the right solution, and we should much regret being the means of putting any stumbling block across the path of a *bonâ fide* venture. Perhaps the Secretary will further explain the intended *modus operandi*.

WE were certainly under the impression that everything mentioned in our Notes columns by M. Henri de Parville relating to the so-called electric sunstroke was perfectly well known to all electricians who have experimented with arc lamps of great candle-power. It was our fortune, or misfortune rather, to experience all that the French writer has embodied in his communition to the *Journal des Debats* twelve or fourteen years ago, when engaged, day after day, in experimenting with the old type of Gramme machine and Serrin arc lamps.

AT length and at last! There has been a rattling of the dry bones, or of the bones we were beginning to fear were dry, and as a result of the unusual commotion London is to be enabled to speak to Birmingham and Birmingham to London. The provincial papers, of course, are all agog with excitement, and are treating their readers to evidences of their wondrous knowledge of a wonderful instrument. One anticipates "the happy day of the penny telalogue." "It will come—it is fast coming; but probably it will not dawn until all the telephonic patents become public property." So that we have still a long time to wait for the penny telalogue. Another seems to think that the result of the contemplated trunk line to Birmingham will be to place all the great provincial towns in communication with London. If "all the great provincial towns" are situated in the Midlands and in Lancashire, Cheshire, and Yorkshire, probably this will be accomplished; but we must not proceed too fast all at once, and if Birmingham is connected with the United system in the Metropolis this year, we must be content to wait till next for speaking facilities with Glasgow, Edinburgh, and Aberdeen, Bristol, Exeter, and Plymouth, Portsmouth, Southampton — we had almost said Brighton.

THERE is still uncertainty in the copper market, although a little variety has been imparted to the proceedings by a cessation in the upward tendency of prices, followed by a slight decline. Whether this is due to a natural reaction resulting from increased output by several mines over which the French syndicate has as yet acquired no control, or whether it is the direct consequence of the manipulators' tactics, and intended to facilitate the acquisition by them of the copper now in other hands, does not seem very clear; but, whatever the cause, it is generally conceded that the syndicate still controls the market and is in a position to once more force up prices if that course is in accord with its plans. The projected combination of the copper-producing companies into one huge pool seems to hang fire, and one theory is that the fall has been induced in order to coerce the companies who are holding back by a display of the power which the syndicate possesses. An impression prevails that the latter does not desire to raise the value of the commodity too much, knowing that the higher it goes the greater the inducement for increasing the output of the world, whilst at the same time consumption will be checked. Meanwhile great activity is reported in all copper-producing countries; many abandoned copper mine schemes are being revived, and new ones are being started. It is from America that the syndicate has most to fear, and intelligence has already reached Europe of the intentions of many of the larger mines there to increase their supplies. The policy of the Calumet and Hecla Company, the greatest producers in the world, perhaps, for years past has been to check speculation and prevent over-production on the part of the smaller corporations by selling at figures which, while affording a fair margin to itself, were profitless to many other mines. Prices, however, had fallen so low that this company, in common with several others had resolved to increase its output in order to get reasonable profits. The disastrous fires which occurred in the mines interfered with this intention, as far as the Calumet and Hecla was concerned, and this it was that stimulated the rise which the heavy purchases of the Parisian syndicates had induced. Other American companies are still free to pursue the policy of increased production, however, and it will probably be from this source that the greatest opposition to the French schemes will be met with.

THERE is a general lament throughout the City at the result of the meeting of the Commissioners of Sewers which we reported last week. Disappointment is tempered only by a firm belief that the signing of the contract with the Anglo-American Brush Electric Light Corporation will not be long deferred. The point which caused the reference back to the Streets Committee of its report in favour of the scheme was the omission of a clause providing a penalty upon the company should it fail to carry out its undertaking. This may or may not have been a master-stroke of caution and wisdom on the part of the gentlemen of the sewers, but we should scarcely think the Anglo-American directors would allow it to stand long in the way of the realisation of their hopes. They can fear little, either in the shape of financial inability, or of mechanical difficulty, and, though shrugging their shoulders at the implication of the clause, will no doubt consent to its inclusion, provided, of course, the Commissioners are not too exacting and extravagant in their demands. The protests which have been raised in one or two quarters against the extra cost involved in the electric lighting scheme is likely to meet with very little support from those most immediately concerned, the large ratepayers of the City, that is to say. Of small ratepayers there are few, and even if there were more they would scarcely be conscious of the difference in the amount of their rates caused by the larger expenditure upon the lighting of the city streets. Half-a-farthing in the pound! Who is likely to object to such a rate, seeing the immense advantage it will bring? Our dear friend and enemy, the *Gas World*, with its solitary correspondent who calls himself a ninepin, is wroth because the commissioners do not "let well alone." "Well," in this instance, is not well enough. Thirty times more light is surely worth paying twice as much money for, where more light means greater security in the richest city in the world. The value of the property reposing within the area proposed to be first lighted is well-nigh incalculable. For the better protection of this property, improved illumination of the streets is to be welcomed, and is welcomed by those who own it. The police, in American towns lighted by electricity, have unhesitatingly and unanimously testified to the value of the light as a means of preventing crime and of facilitating the capture of criminals at night.

TRANSMITTING SPEECH BY INTERRUPTED ELECTRICAL CURRENTS.

IN the opinion of Mr. C. J. Kintner, late Principal Examiner Class, of Electricity, U.S. Patent Office, who writes in the *Electrician and Electrical Engineer*, perhaps no better apparatus exists or ever will be devised for demonstrating the absolute correctness of Prof. Bell's undulatory or wave theory than the instruments which bear his name and are so largely in public use to-day.

Two of these instruments connected in a metallic or all-wire circuit act respectively as a magneto generator and a magneto motor; the one setting in motion when spoken to currents of an alternating nature varying in volume, and the other responding to them so that its diaphragm correctly reproduces speech to the listener.

If, therefore, we analyse the action of the transmitting diaphragm we have the substantial action of its fellow at the receiving station; the vibrations being, however, diminished copies of those made by the transmitting diaphragm. If a pure musical tone entirely free from harmonics be uttered into the transmitter, the diaphragm will vibrate in such a manner that the excursions from front to rear will be described in equal times, there being no irregular changes of velocity during any part of the excursion. This action gives a wave curve of regular rise and fall with equal distances between the wave crests. With such a tone, there are two, and only two dead points during each complete vibration of the diaphragm, but at each of these dead points the current on the line is nil, and a reversal takes places in each instance after the said points are passed.

Fig. 1 represents graphically the form of such waves and the volume of current flowing during any particular

FIG. 1.

phase of the diaphragm; a, b being the medial line or position of the diaphragm at rest, plus currents appearing for the advance of the diaphragm, and minus currents for the retraction. The volume of current varies regularly from dead point to dead point, and has maximum values at $+ c\,d$; $- e\,f$ and $+ g\,h$. These currents may be represented algebraically by the following equation:—

$$c = \frac{\mathrm{v}\,t}{d^2},$$

where v is the velocity of the diaphragm; t, the time elapsed since the diaphragm passed the medial line, and d the distance of the diaphragm from the core of the magnet at any point of its excursion. But v may be assumed to be constant for any interval of time, since the power due to this particular sound wave is a constant, so that the velocity tends to be of a constantly accelerated nature, but is in fact opposed by a constantly increasing power in the opposition of the diaphragm under its increasing elastic stress. This equation shows that the current is nil at the start and that there is generated during the advance of the diaphragm, a plus current of constantly increasing volume until the value of d has diminished sufficiently to change its volume, when it will decrease till the first dead point is reached, where it is again nil. Now a reversal takes place in the motion of the diaphragm and a minus current is set up which increases in volume, until d grows sufficiently large and v sufficiently small by reason of the increased elastic strain of the diaphragm to stop such increase, after which it decreases until the second dead point is reached when the current is again nil, thus alternating gradually varying impulses are set up in the line, or more properly alternating waves, which merge into each other so gradually, that like the swinging of a clock pendulum it is impossible to ascertain just where they begin or cease. In the transmission of this pure tone actual breaks of exceedingly small duration in the flow of the current may occur at these dead points, and not materially mar the tone copied at the receiving instrument, for the reason that the vibrations have symmetrical or regular recurrence. If this had been the whole problem in the transmission of speech by electricity it would have been very simple, and Philip Reis would have solved it when he invented his musical telephone. But there is another element which enters into the problem when we come to transmit composite tones like those of the human voice. This element was the stumbling block in the path of Reis, and it was Professor Bell's magneto instrument that led him to discover it. I refer to the overtones or divisional tones into which the fundamental tones merge. These tones exist, and are detected by delicate ears as low as the fourth order. Each order necessarily complicates matters and makes the problem the more difficult, but the magneto telephone solves the whole matter by causing its diaphragm to shape or conform itself to the resultant power of the sound waves, and each overtone on the advance of the diaphragm causes it to be retarded sufficiently to reverse the direction of the current or to diminish its effect, or if of such a nature as to aid the fundamental tone, then increased volumes are added to the fundamental volumes for the smallest imaginable fractions of a second, while any overtones on recessions of the diaphragm cause corresponding retardations and reversals or advances of the diaphragm on its back vibration. In other words, the diaphragm passes from the point of absolute rest to its fundamental dead point by a succession of direct, differential direct, and differential retrograde motions due to the combined action of the fundamental tone and overtones of all the orders. By this combined action of the fundamental tones with the overtones a prevailing plus impulse of electricity is generated, which is decreased and increased materially in its volume at specified points, which I denominate the overtone dead points, by the reverse and direct action of all such overtones. As a matter of fact this direct current impulse is actually overcome at some points of the diaphragm's excursion. On reverse action a similar series of effects occur, giving a minus fundamental impulse aided and opposed during its progress by the direct and reverse actions of the overtones which occur on that side, that is to say, during the back action of the diaphragm due to its elastic effect. With this action of the diaphragm there is found upon the line a series of electrical waves made up of a plus fundamental current, aided or retarded, as the case may be, by overtone currents of various orders combined in effect; and minus fundamental waves similarly aided or retarded during the back action of the diaphragm. In one sense of the word these currents are intermittent at stated points, but it may be asked, if they are intermittent, who can tell where they commence and where cease? One fact is patent: namely, that there is no apparent actual intermission, and that the current volume changes during all the phases of the diaphragm in accordance with all of the sound waves, both composite and simple. Strictly speaking, Professor Bell is theoretically right in calling the electrical effects waves, for there is no positive discontinuance of current which can be detected at any time, and their rise and fall in volume and regularity are entirely analogous to those of liquid waves even though one set be plus and the other minus. In fact, in actual liquid waves we have the same positive or upward action and negative or

downward action, so that the simile is not a bad one. In fig. 2 I have shown the form of electrical waves due to the combined action of the fundamental and overtones, *a*, *b* being the medial line of the diaphragm. From *a* to *c* the diaphragm is advancing under the action of a fundamental tone, but at *c* it is checked by the action of one or more reverse overtones. This combined action of the advanced fundamental tone and reverse overtones diminishes the volume of current by reason of the resultant action of the two tones, as shown by the cross-section at *x*, *x*. From *c* to *d* an increase due to the fundamental again occurs, but at *d* the combined overtone effect reverses the direction of the diaphragm and a minus current of small volume is generated, the diaphragm going back to the point shown by the ordinate *d* 2. From *d* 2 to *d'* the fundamental gives an increased current volume which is aided by a positive or plus overtone at *d'*, giving an increased current as shown by the cross-section at *z*, *z*. Similar results take place at the other points of the diaphragm's excursion, as will be seen at *f*, *g*, *h*, *l*, *j*, &c. An analysis of this figure shows that there is a gradual rise and fall in the current volume for the fundamentals not unlike that shown in fig. 1, but it also shows that the overtones vary this rise and fall, sometimes increasing and sometimes decreasing the volume of current due to the fundamental. Of course the figure is not mathematically accurate in its graphical representation of the currents generated, but it is sufficiently accurate to show the correct nature of the currents generated or set up by a magneto telephone.

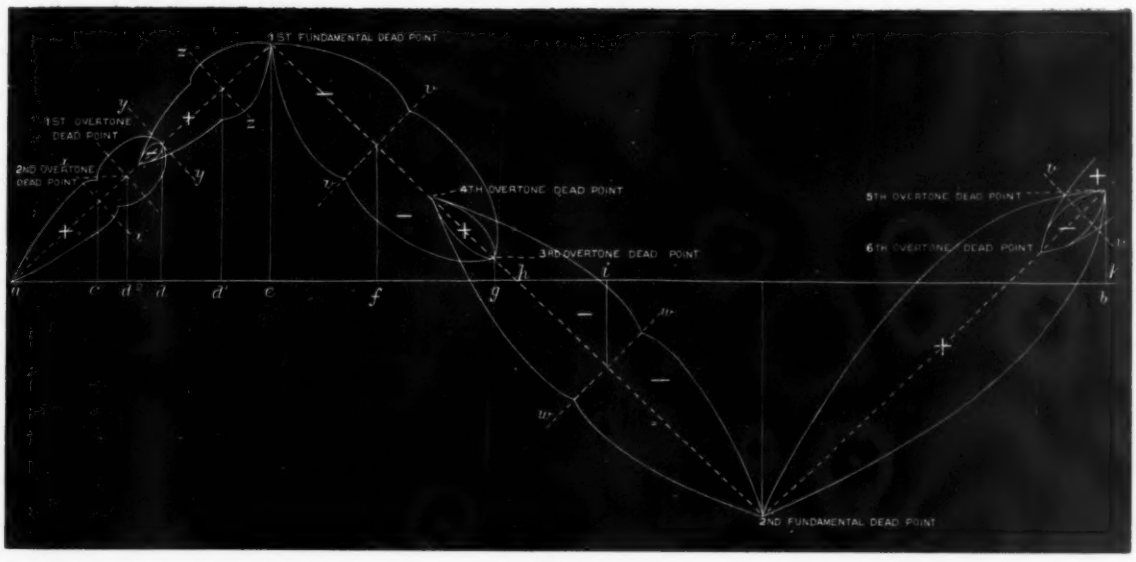

1ST FUNDAMENTAL DEAD POINT
1ST OVERTONE DEAD POINT
2ND OVERTONE DEAD POINT
4TH OVERTONE DEAD POINT
3RD OVERTONE DEAD POINT
5TH OVERTONE DEAD POINT
6TH OVERTONE DEAD POINT
2ND FUNDAMENTAL DEAD POINT

FIG. 2.

If the diaphragm is sufficiently delicate in the transmitter every peculiarity of the sound waves is accurately copied, and it in turn, by the action described, creates or sets up electrical waves entirely similar to the sound waves. No form of contact telephone with which I am familiar will give such accurate results as these magneto instruments; because contact telephones cannot be made so delicate, and also for the reason that they act to change the volume of an existing current and must be more or less clumsy in their construction and action, while the magneto sets up only the current actually needed; the diaphragm being free to copy accurately every peculiarity of the sound waves. The nearest approach to the perfect action of the Bell instruments is found in the microphone, but even it fails in many respects because of imperfections, such as bad contacts, irregular conductivity, sparking, dust, &c., &c.

With this discussion of Prof. Bell's theory, I am prepared to pass to the problem of transmitting speech by actual impulses or breaks, and shall endeavour to show in the next article that it is entirely possible, provided the current impulses or breaks correspond to the overtones as well as the fundamentals in the voice of the speaker. I do not maintain, however, that the speech will be as pure as that transmitted by the magneto instruments, as, indeed, it is not with many contact telephones now in use, but I shall show that it is still possible to transmit speech which shall serve commercial purposes and not infringe Prof. Bell's 5th claim before referred to. (See *Electrician and Electrical Engineer*, vol. vi., No. 71, p. 451.) The method relied upon will be, by current impulses equal in volume but differing in duration in direct proportion to the fundamental and overtones combined; the instrument for executing this method being such that the electrodes shall vibrate in direct unison with the diaphragm during all its phases.

(*To be continued.*)

SIEMENS AND HALSKE'S IMPROVED PACCINOTTI DYNAMO.

IN dynamo-electric continuous current machines constructed with the Paccinotti ring, the poles of the exciting electro-magnets are situated opposite the outer surfaces of the ring. With this arrangement the poles have, in addition to those surfaces that face the ring and that are consequently operative, other surfaces of comparatively large extent that do not face the ring and that are consequently inoperative, and that is more particularly the case when the axes of the exciting magnets depart materially from the radial position. If on the other hand, in order to utilise the whole of the polar surfaces, they are placed so as to face the ring, long connecting pieces are required between the parts of the magnet that are directed away from the ring, more particularly when these are arranged in more or less radial positions. In the first named case a large portion of the magnetic force produced passes from the inoperative surfaces of one magnet to corresponding surfaces of the next magnet forming magnetic lines of force that are not cut by the revolving coils of the armature. This defect was not improved by so forming the poles as to extend round to the inner surface of the ring; on the contrary, the quantity of lines of magnetic force that are given off without being operative are only increased by this arrangement. In the second above mentioned case the long connecting pieces operate very detrimentally by weakening the magnetism produced. Endeavours have been made to increase the power of the external poles by the use of

separate electro-magnets having their poles so arranged as to face the inner surface of the ring, but such magnets have only an insignificant action as compared with the external magnets on account of their small size.

The invention of Messrs. Siemens and Halske consists in employing for such continuous current ring machines exciting electro-magnets that are situated entirely within the ring armature, which is for this purpose made of a large size, so that the outwardly directed polar fields face the inner surface of the ring, the limbs of these electro-magnets being made as massive as possible, either with or without extension of the polar fields.

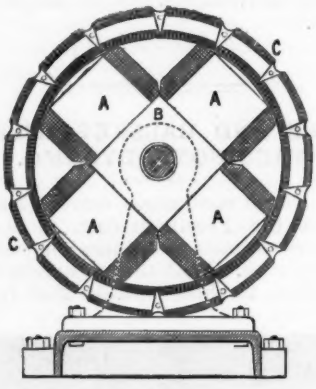


FIG. 1.

With this arrangement either a single pair or several pairs of electro-magnet limbs may be used, such limbs being either in line with each other when only one pair is employed, or arranged in a cross or star shape when two or more pairs are used.

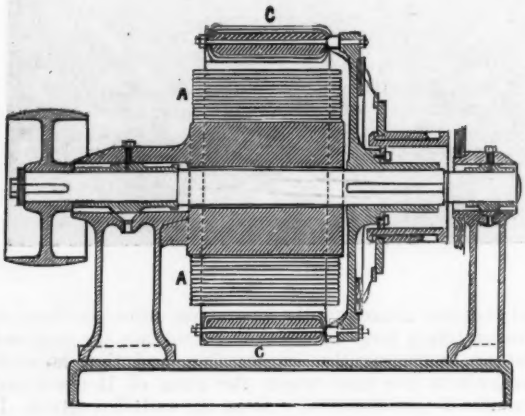


FIG. 2.

The peculiar features and advantages of dynamo-electric machines thus constructed are: firstly, that nearly all the magnetic lines of force emanating from the poles of the electro-magnets are cut by the revolving ring armature, and are therefore utilised; secondly, that the parts of the electro-magnets that are directed away from the ring towards the centre of the latter only require a very short magnetic connecting piece, so that the detrimental magnetic resistance, due to the connecting pieces, is in this case reduced to a minimum; thirdly, that as all magnetic lines of force are, so to speak, intercepted by the ring and utilised, the improved construction will only have a small amount of so-called free magnetism, operating outwardly and at a distance, which magnetism has a very detrimental and dangerous effect both in the measuring instruments employed in electrical installations, and on the proper working of ships' compasses, when such machines are used on board vessels.

Figs. 1 and 2 show respectively a cross-section and longitudinal section of a dynamo-electric machine constructed according to the invention. A, A, A, A, are four radially arranged electro-magnets, whose inner poles are attached to the common central connecting piece, B, while the outer poles are presented to the inner surface of the Paccinotti ring, C.

ON THE INDUCTION ERROR IN THE MEASUREMENT OF ALTERNATING ELECTROMOTIVE FORCES BY SIR WM. THOMSON'S "VERTICAL SCALE VOLTMETER."

By THOMAS GRAY, B.Sc., F.R.S.E.

THE extensive and rapidly-increasing application of alternating currents for electric lighting and other purposes, and the apparently wide-spread uncertainty as to the measurements involved, has suggested to me that the following description of Sir William Thomson's "vertical scale voltmeter" for the measurement of alternating electromotive forces, and the accompanying investigation of the effect of self-induction in each coil, and of mutual induction between its coils, on the indications of the instrument may be of interest. One form of this instrument has already been described in these pages, but the form here shown embodies some important modifications, recently made, by which it is rendered more convenient and accurate when used with continuous currents, and which have the advantage of making it somewhat more suitable for alternating currents. Referring to figs. 1 and 2, two round coils of circular cross section, *a* and *b*, are fixed at the two ends of a light aluminium frame, *c*. This frame is suspended from two round pins, *d* and *e*, carried by brass knee pieces, *f*, *g*, in such a way that the planes of the coils are parallel to the sole-plate. The suspension consists of two flat ligaments, *h*, each made up of 20 fine copper wires, the upper ends of which are soldered to the pins, *d*, *e*, and the lower ends to two brass tubes fixed on, but electrically insulated from, a cross trunnion, *l*, which forms part of the frame, *c*. The frame, *c*, and the two coils attached to it, form the movable part of the electro-dynamometer. The fixed part consists of two circular coils, *m* and *n*, of square cross section, and of the same mean radius as the movable coils. One of these is placed below *a* with its centre opposite and its plane parallel to that of *a*. The other is similarly placed *above b*. These coils are connected in series in such a way that when a current is passed through them the fixed coils, *m* and *n*, repel the movable coils, *a* and *b*. The force of repulsion is balanced by a cylindrical weight placed in a V-trough, *o*, fixed to the end of the beam with its length parallel to the plane of the suspension ligaments, and, as the force of repulsion diminishes with increase of distance between the repelling coils, the beam assumes a definite position of equilibrium for any value of current within the range of the instrument. In order to render the position of the coil easily read, the short end of a light aluminium index, *p*, is connected to the coil, *a*, by a link, *q*. The index turns round a knife edge resting on a platform, *r*. The knife edge is prevented from moving in the direction of its length by end plates, and the index is kept in the proper plane by passing the ends of the knife edge across V *s*, the angles of which are in the plane of the platform, *r*. The end of the index, *p*, shows the motion of the coil magnified eight times on the scale, *s*, which is commonly graduated with divisions ranging from 90 to 110, thus giving a twenty per cent. range. The indications of the instrument are affected by any want of balance of the beam or by a change in its stability. In order that these may be adjusted, a horizontal screw, S_1, and a vertical screw, S_2, are provided.

The beam is adjusted for stability by the maker, and this does not generally require to be readjusted unless the beam becomes bent through some accident or the screw be accidentally moved. The stability is made so small that about one-thousandth of the ordinary working force turns the beam from the division 100 to division 90. The balance of the beam in this double form gives little or no trouble, but it is well before any important observation is made to see that it is exact. A key, K, is provided on the instrument so that the circuit can be broken at any time and the balance tested. The beam is balanced with the weight in the trough, *o'*, at the right-hand end of the beam. After the balance is adjusted the weight is transferred to the trough, *o*, at the left-hand end of the beam. This method of working avoids any chance of a change of the constant of the instrument due to any bending or other change of the ligament producing a displacement of the position of the virtual axis of the beam. Should the index, *p*, become bent, or the link, *q*, lengthened, the indications of the instrument would, of course, be changed, and to avoid error from this source a zero mark, *t*, is made a short distance above the scale graduation, and the end of the index is made to point to that mark when the beam is resting against its stop, or when no current is passing. In order that this adjustment may be easily made, and also that the plane of motion of the index may be readily adjusted to coincide with the plane of the scale, *s*, the platform, *r*, can be raised, lowered, or turned in azimuth. The whole of these fittings are mounted on a strong sole plate of slate, P, to the underside of which is attached a copper ring, *k*, on which is wound a double wire of platinoid of the requisite resistance to make the indications of the pointer on the scale, *s*, be volts. Great care is taken in the construction of the instrument that its indications for alternating currents are in no way affected by currents induced in any part of the framework. Thus the movable coils are simply solidified by paraffin and bound round with silk tape, while the two sides of the aluminium frame on which they are carried, and which forms the beam, are insulated from each other at the ends. The bobbins for the fixed coils are slate, the sole plate is slate, and the copper ring beneath it is cut through at one side and bound together by a strip of vulcanite.

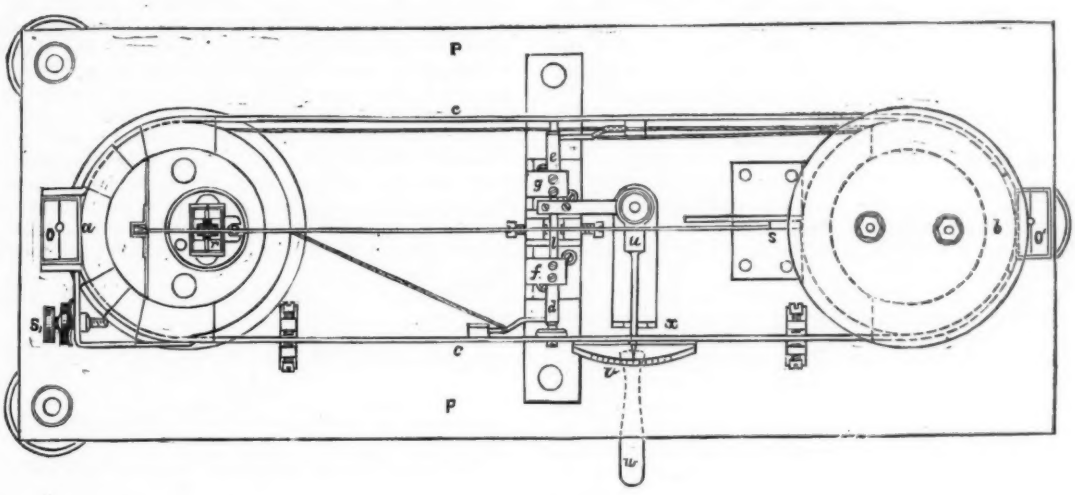


FIG. 1.

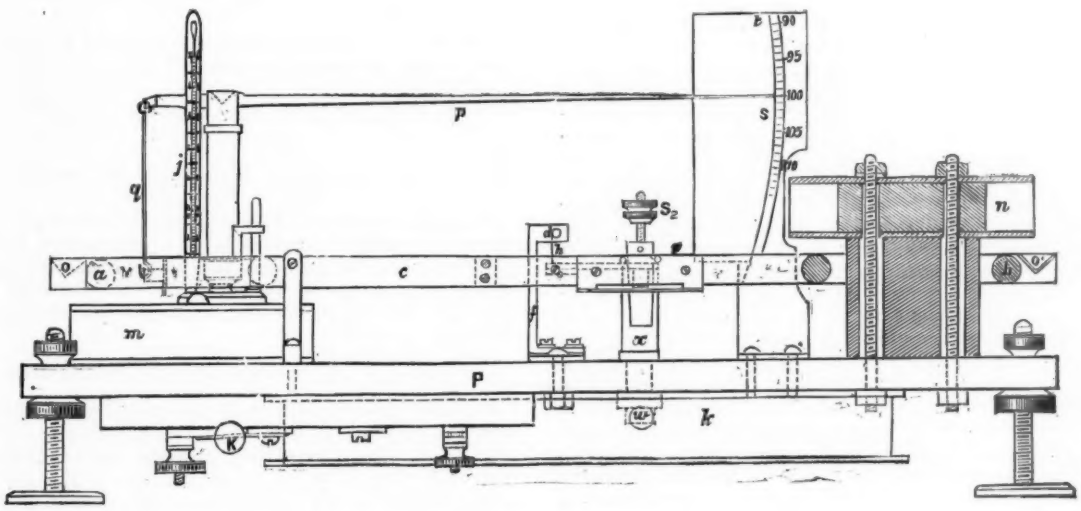


FIG. 2.

Objections have been made to the use of an instrument of this type for the measurement of electromotive forces, mainly for two reasons. First, that the indications are affected by the temperature of the coils, and second, that for alternating currents the effect of self and mutual induction is likely to considerably alter the indications.

The first of these objections is met in these instruments by inserting the bulb of a thermometer, *j*, in the

centre of the bobbin of the coil, m, and providing a correcting flag, u, turning above a scale, v, so graduated that when the flag is over the same number as the thermometer indicates there is no temperature error. This flag can be turned from the outside of the case by means of the handle, w, which turns the flag when necessary by means of a fork, x, which is left out of contact in the ordinary use of the instrument. When the instrument is standardised the electromotive force corresponding to the division 100 of the scale is kept on the terminals for a sufficient time to allow the thermometer indication to become steady, and then the weight required to bring the index to that division is determined. The position of the flag during this determination is taken as the zero of its scale and a proper scale is then added, depending on the weight and form of the flag, and the temperature variation of the coils of the instrument, to give the requisite temperature correction. The flag must always be brought to this position when the adjustment of the balance of the beam is checked. It is clear from the method of determining the constant, together with the fact that the total heating is only a few degrees, that when the instrument is kept continuously in circuit, as it is intended to be, the correction for temperature is practically only required for variations of external temperature, and this is very exactly allowed for by the method here indicated.

The effect of induction in impeding the currents flowing through electro-dynamic instruments when subjected to alternating or varying electromotive forces depends on the coefficients of self-induction of the individual coils, and the coefficient of mutual induction between the different groups of coils, combined with the rate of variation of the current. It is usual in investigating this effect for alternating currents to assume that the E.M.F. varies according to the simple harmonic law, that is, that the value of the E.M.F. at any time, t, can be expressed in the form $\text{A} \sin. \frac{\pi}{\tau} t$, where A is the maximum value of the E.M.F. and τ half the complete period of alternation. The same assumption has been made in the investigation given below, not because I believe that it gives an exact expression for the variation of the E.M.F. produced by all the forms of alternating dynamos now in use, but because I believe the result gives a fair idea of the probable error of the instrument, slightly wrong, no doubt, but about as likely to be against as in favour of the instrument. The tendency in some of the newer forms of dynamo seems to be to give a curve of variation of electromotive force approximating to a series of equal triangles, with their vertical angles necessarily slightly rounded off. This, however, is by no means a very bad form of curve so far as the effect on an electro-dynamic voltmeter is concerned. It would probably sensibly affect a wattmeter in consequence of sensible difference of phase between the currents in the fine coil and the E.M.F. on its terminals, but this is outside the scope of the present investigation. All good dynamos produce a fairly smooth curve, and given this curve there is no insuperable difficulty in calculating to a sufficient degree of approximation the error of an electro-dynamic instrument, the induction coefficient of which is known.

The following are the particulars of the sizes and approximate number of turns in the coils of Sir William Thomson's balances designed to measure from 90 to 110 volts.

Mean radius for all four coils ...	4	centimetres.
Radius of cross section for movable coils	0·5	"
Side of square section for fixed coils	2·0	"
Distance from centre of fixed to centre of movable coil	2·5	"
Number of turns in each movable coil	380	
Number of turns in each fixed coil	670	
Total resistance of instrument ...	640	ohms.

The coefficient of self-induction of a circular coil can be calculated with sufficient accuracy for our present purpose from the following equation (Maxwell "Electricity and Magnetism," 1st edition, Vol. II., p. 311).

$$\text{L} = 4\pi n^2 a \left\{ \log. \frac{8a}{r}\left(1 + \frac{3}{16}\frac{r^2}{a^2}\right) - \frac{1}{16}\frac{r^2}{a^2} - 2 \right\},$$

where n is the number of turns in the coil, a its mean radius, and r the geometric mean distance of its cross section. The same equation applies to the determination of the mutual induction between two coils if for r we take the geometric mean distance of the cross section of one coil from the corresponding cross section of the other coil, that is, the geometric mean distance between the coils, and for n^2 the product of the numbers of turns in the two coils. (For the meaning of the term "geometric mean distance," see Maxwell's "Electricity and Magnetism," vol. ii., p. 294.) The value of this quantity for the movable coils of the instruments here considered is 0·389 centimetres; for the fixed coils 0·894 centimetres; and for the distance between the fixed and movable coils only very slightly greater than the distance between the centres of their cross sections, which is 2·5 centimetres for the mean position of the movable coil, substituting these values in the above equation we get the following values :—

Coefficient of self-induction of each movable coil (L_m) :

$$\text{L}_m = 16 \times 3{\cdot}1416 \times 380^2 \left\{ 2{\cdot}303 \log \frac{32}{{\cdot}389}\left(1 + \frac{3 \times {\cdot}389^2}{16^2}\right) - \frac{{\cdot}389}{16^2} - 2 \right\} = 175 \times 10^5 \text{ centimetres.}$$

Coefficient of self-induction of each fixed coil (L_f) :

$$\text{L}_f = 16 \times 3{\cdot}1416 \times 670^2 \left\{ 2{\cdot}303 \log \frac{32}{{\cdot}894}\left(1 + \frac{3 \times {\cdot}894^2}{16^2}\right) - \frac{{\cdot}894^2}{16^2} - 2 \right\} = 362 \times 10^5 \text{ centimetres.}$$

Coefficient of mutual induction for each movable or fixed coil in the mean position of the movable coil (M) :

$$\text{M} = 16 \times 3{\cdot}1416 \times 670 \times 380 \left\{ 2{\cdot}303 \log \frac{32}{2{\cdot}5} \left(1 + \frac{3 \times 2{\cdot}5^2}{16^2}\right) - \frac{2{\cdot}5^2}{16} - 2 \right\} = 911 \times 10^4 \text{ centimetres.}$$

Now, bearing in mind that since the coils repel each other, the mutual induction is of opposite sign to the self-induction, we see that the whole inductive impedence is proportional to the difference between the self and mutual induction; call this quantity I, and we have

$$\text{I} = 2\,\text{L}_m + 2\,\text{L}_f - 4\,\text{M} = 71 \times 10^6 \text{ centimetres.}$$

Consider now the effect of the quantity, I, in impeding the current. Let R be the total resistance of the instrument circuit supposed, with the exception of the instrument coils, to be inductionless; E the electromotive force at any time, t, and c the current flowing at that time.

Then

$$\text{R}\,c = \text{E} - \text{I}\frac{d\,c}{d\,t}.$$

We may assume without much error that if E_0 is the maximum value of the alternating electromotive force, and $2\,r$ its period of alternation,

$$\text{E} = \text{E}_0 \sin. \frac{\pi}{r} t.$$

Hence we have

$$\text{I}\frac{d\,\text{C}}{d\,t} + \text{R}\,\text{C} - \text{E}_0 \sin. \frac{\pi}{r} t = 0.$$

This equation when integrated gives for the square of current

$$C^2 = \frac{1}{2} \frac{E_0^2}{R^2 + \pi^2 \frac{I^2}{r^2}}$$

This is the quantity on which the force between the movable and fixed system of coils depends, and the indications of the voltmeter are thus proportional to

$$\frac{E_0}{\sqrt{R^2 + \pi^2 \frac{I^2}{r^2}}}.$$

It would be $\frac{E_0}{R}$ simply if there were no inductive impedence.

Each value of the current, and consequently of the indication of the instrument for a given E.M.F., is thus diminished in the ratio of R to $\sqrt{R^2 + \pi^2 \frac{I^2}{r^2}}$. Suppose that r is equal to ·005, or that there are 12,000 alternations per minute, rather a higher number than is commonly used in alternate-current installations, that at the Grosvenor Gallery, for instance. Then for our case

$$\frac{R}{\sqrt{R^2 + \pi^2 \frac{I^2}{r^2}}} = \frac{1}{\sqrt{1 + \frac{\pi^2 I^2}{R^2 r^2}}}$$

$$= \frac{1}{\sqrt{1 + \frac{499 \times 10^{14}}{1024 \times 10^{16}}}}$$

$$= \cdot 9976$$

The effect is thus for the case considered, which is not by any means the most favourable one that could be obtained, only about a quarter per cent. It is therefore quite clear that a voltmeter on the electro-dynamometer principle can be made to measure with great accuracy the square root of the mean square of the electromotive force on the circuit. It follows, of course, that the variations of the current through such an instrument will agree almost perfectly in time and phase with the electromotive force, and hence that a wattmeter on this principle will measure very approximately the rate of working in the circuit. It should be remembered, however, that in a wattmeter the currents through the potential coils of the instrument must have the same phase as the electromotive force on the main leads to which it is connected.

The accuracy of the indications of an electro-dynamic voltmeter may be easily tested experimentally if another instrument either of the same or of a different class is available to be used as an indicator of the same potential for any one set of experiments. Let the two instruments be compared when a constant E.M.F., from a battery if possible, is sending a current through them joined in parallel. Increase the non-inductive resistance of the electro-dynamic instrument and again compare the constants of the two instruments. Place them then on the alternate current circuit, their terminals joined as before to the same points and, keeping the rate of alternation constant, compare the constants of the two instruments in the same way, altering the electromotive force, if possible, so as to obtain the same reading on the electro-dynamometer, which is being tested, for the first reading. If there is no effect of inductive impedence on the indications of the instrument the ratio of its constants for the two values of the non-inductive resistance will be the same with constant and with the alternating E.M.F. If the ratio of the constants differ sensibly in the two experiments, we may determine the error of the instrument from the equation $E_0 = E\left(1 + \frac{\pi^2 I^2}{R^2 r^2}\right)$ where E_0 is the true electromotive force, E the indication of the instrument, and R the total resistance in its circuit. Let $\frac{\pi^2 I^2}{r^2} = A^2$, and we have from the first experiment with alternating E.M.F.

$$E_0^2 = E_1^2 \left(1 + \frac{A^2}{R_1^2}\right),$$

and from the second experiment

$$E_0^2 = E_2^2 \left(1 + \frac{A^2}{R_2^2}\right).$$

Hence we have

$$E_1^2 \left(1 + \frac{A^2}{R_1^2}\right) = E_2^2 \left(1 + \frac{A^2}{R_2^2}\right)$$

$$\therefore A^2 \left(\frac{E_2^2}{R_2^2} - \frac{E_1^2}{R_1^2}\right) = E_1^2 - E_2^2$$

and

$$A^2 = \frac{E_1^2 - E_2^2}{\frac{E_2^2}{R_2^2} - \frac{E_1^2}{R_1^2}}.$$

Since $A = \frac{\pi I}{r}$ this equation gives a means of determining the algebraic sum of the self and mutual induction of an instrument.

Another good experimental method is to compare two instruments of precisely similar type but of different known coefficients of induction, both with constant and with alternating E.M.F.s. or currents. The calculation is precisely similar to that just given, I taking the place of R. This is a much better method than the comparison of two instruments of different types, as, for instance, an electro-dynamic voltmeter and a Cardew voltmeter.

CONDUCTORS FOR HOUSES.

By G. L. ADDENBROOKE.

IN a previous article the wiring of houses was treated from a general standpoint. On the present occasion it is proposed to go more particularly into some of the questions which arise in wiring, as to the most suitable sizes for conductors, and some other points concerning them.

As regards the material of the conductors themselves, it goes without saying that it will almost certainly be copper. The improvements in the processes of manufacture of copper during the last few years have been very great, and what is called high conductivity wire obtained from good makers will now be found to average 98 per cent. conductivity, consequently there should never be any difficulty in obtaining the usual commercial standard for electrical work of 96 per cent. conductivity.

It may be interpolated here that, considering the strides which the science of electricity has made, and the improvements which have taken place in the reduction of metals and the extraction of impurities from them during the last few years, and seeing the chaotic state of the tables of relative conductivities of metals put forth by various authors, it would be a real service to the electrical world if some competent authority would undertake a fresh series of investigations on this subject, which, important as it is from a commercial point of view, is even more so from a theoretical one.

Assuming, then, a basis of 96 per cent. conductivity, according to Mathiessen's standard for the copper wire, we next come to the question as to what is, on the whole, the most convenient and economical sectional area of conductor to carry a given current. Theoretically, this has been gone into very carefully, and we have Sir William Thomson's formula, with tables constructed from it, in which, given the price of copper, the rate of interest, and the cost of energy, we can at once determine the most economical size of conductor by means of which a given current may be delivered at any given distance from a central station. But the formula gets enormously involved and quite too complicated for commercial use, when the question becomes, as it almost always is in practice, one of delivering current (in ever varying quantities) from

mains into numerous branches in parallel. Further, these branches will all be at different distances from the centre of supply, while it is most essential that the difference of potential in the mains should not vary more than 1 per cent., consequently some general approximate solution of the problem must be sought.

In lighting houses from central stations there are two distinct but similar problems to be solved, the first is to determine how to be able always to deliver in to any customer's house the quantity of current he is likely to require at a constant fixed potential. The second problem is to distribute that current from its entrance into the house to the terminals of the lamps, so that whether a part or all of them are burning, the difference of potential at the terminals of each may be as nearly the same as possible. With the first of these questions we are not concerned here. As regards the second, it is not of such consequence to secure full E.M.F. at the terminals of the most distant lamps in dwelling houses when the upper rooms are usually bedrooms, as it is in offices and workrooms, where as good a light is essential on the top floor as on the bottom.

Now custom seems gradually to be establishing, and contractors are settling down to using wires of such a size that when carrying their full current the density equals 1,000 ampères per square inch. Consequently it is desirable to get a definite notion in as simple physical terms as possible of the exact meaning and implication of "1,000 ampères per square inch."

Taking copper to weigh 555 lbs. per cubic foot, a square rod of copper, one mile long and of one square inch sectional area, would weigh 20, 350 lbs., and its resistance at 96 per cent. conductivity would be about ·0458, or $\frac{1}{22}$ ohm at 75° F. For rough mental calculations for wiring purposes, it will be sufficiently near to assume that the resistance of the above length and area of copper wire is $\frac{1}{20}$ ohm at ordinary temperatures. Now to pass 1,000 ampères through $\frac{1}{20}$ ohm needs an E.M.F. of $1{,}000 \times \frac{1}{20} = 50$ volts. That is, at a current density of 1,000 ampères per square inch, the resistance of the conductor will absorb 50 volts potential in each mile of length. Now a mile is 5,280, or say, roughly, 5,000 feet; therefore putting these facts into their briefest and simplest form, a volt potential will be lost in every 100 feet of conductor when the current flows at the rate of 1,000 ampères per square inch sectional area. Or if we take into consideration the outgoing and incoming wires, a volt potential will be lost for every 50 feet the leads are carried.

This is a fact worthy to be borne in mind more fully than it usually is in wiring houses. For there are few houses in which the leads do not run a greater distance than 50 feet from the point of entrance of the mains, and a volt difference in potential makes quite a perceptible difference in the brightness of even a 100-volt lamp, and consequently a much greater difference in a lamp intended for 60 or 50 volts. In public buildings and theatres with lofty roofs, where the leads are often over 100 feet in length, and all the lamps are usually burning at the same time, the area of the conductor is really a question demanding very careful consideration. The ordinary 16 candle-power lamp gives none too much light when run at its full candle-power, and if leads are put in at the 1,000 ampères rate, as they usually are now, and two or three volts potential are lost by the time the current reaches the lamps, the light will be very much poorer and redder than it should be, and the public will be correspondingly disappointed. It may be unhesiatingly affirmed that contractors are not justified in wiring public buildings, nor should those responsible allow such work to be carried out at the 1,000 ampère rate. The current density should not be more than half this, viz., 500 ampères per square inch, or even less, according to circumstances.

It is the more necessary to remember these points now that the introduction of the Welsbach and other kindred incandescent gas burners, the use of which is rapidly extending, has given people a really beautifully white gas light, while at the same time the consumption of gas is much more moderate with them than with the ordinary burners, against which the incandescent lamp has so far had to compete. Certainly the new form of refractory mantle is extremely brittle, and has other disadvantages; but it would be short-sighted to assert that now its manufacture has assumed such commercial importance, experience in this field will not result, as it has resulted in all other cases, in great improvements in construction.

In wiring a house or public building, a sketch of the conductors and branches should be made with the number of lamps on each. If the lengths are then roughly measured or estimated, and put on the plan, keeping in mind the rule given above, and with the aid of a table of the capacity of each diameter of wire, it will be easy in a few minutes to work out the sizes of conductors for each section, so that while on the one hand improper loss may be avoided, on the other hand no unnecessary expenditure in copper may be incurred.

Such a plan should always be made and left with the householder or other responsible person when a house is wired. If, as is often the case, the work is anywhere at all complicated, or a good deal of it hidden, a sketch plan of this kind is of great service should any subsequent alteration be required or anything go wrong, since by its aid the course of the various conductors is easily traced, whereas without some such guide, frequently several lengths of casing have to be taken down, or several boards got up, before a clear idea can be formed as to how the conductors are arranged, and how to set about what is intended to be done.

On the question of stranded *versus* single conductors, it seems to me that this is a point which circumstances may quite well be left to decide in each case. With the class of copper wire now used for electrical work there need be no fear of its ever breaking, unless it is exposed in a place where it is liable to be frequently bent backwards and forwards to an abnormal extent. The chief reasons why it is inadvisable, as a rule, to use solid copper wire of greater section than No. 12 S.W.G., are the difficulty in making neat joints with it of a moderate size, and the fact that above this diameter the wire is so stiff and springy, that it is difficult to get it to lie neatly in the grooves of casing or in channels cut out for its reception. Therefore, as a general rule in specifications, it is perhaps better on the whole to arrange that solid wire above No. 12 should not be used.

The subject of joints is always a rather difficult one. Electrically resin is a perfectly satisfactory flux, but mechanically it is not by any means so. On the other hand, the acid chloride of zinc, or other similar fluid, usually called "spirits" while perfect as a flux mechanically, is by no means so electrically, from the difficulty of getting rid of it after its work is done, and if it remains present, its hygroscopic nature is sure to cause dampness and start chemical action. This tendency can be got rid of by sponging the wire after the joint is made with clean water and letting it dry before the insulation is applied, but workmen cannot always be trusted to do this. On the whole, perhaps, it is best to effect a compromise, and use resin for all joints up to and including 7/16. Above this size it is a difficult and uncertain operation when resin is used as a flux, getting the solder to take properly and getting it to flow nicely between the strands and fill up the interstices, which is of importance to preserve the conductivity and strength of the joint. Therefore, for the larger sizes of stranded conductors, especially when there are 19 or more strands, it is preferable to use "spirits" for soldering, making a neat joint by cutting the core out of one conductor for about 3 inches and the outer layers of strands of the other, bringing the two together, and, if necessary, binding them round with some fine copper wire to keep the whole firm. With a little care the joint can then be run quite solid, and a few spongefulls of water, followed by the application of a clean iron to dry up the moisture will put matters quite straight, as far as any evil after consequences are concerned.

There is another point to which, if a little more care and attention were generally devoted, many small mishaps, and some rather awkward accidents, would from time to time be avoided. I refer to the connection of conductor with switchboards, cut-outs, &c. There are two methods by which this is ordinarily affected. By passing the conductor through a hole in a brass terminal, a screw driven down at right angles on the conductor serving to keep it in its place, or by turning round the end of the conductor, making a sort of eye of it, which is then clamped under the head of a large square-headed screw.

There are objections to both these methods. To the first, that such terminals for the larger sizes of conductors are very bulky and unsightly, and further that the clamping screw is very liable to cut the strands of the conductor, especially if the conductor ever has to be moved after being once fixed. To the second, that it is not always an easy matter to clamp a lot of strands firmly under the head of the screw; they are very apt to shift about, and, if the conductor is moved or knocked, the screw works loose.

A much neater and preferable method is to take a piece of suitable copper-strap, bore a hole in one end of it, sufficiently large to take the shank of the square-headed screw, and taper the other end down so that it can be inserted between the strands of the conductor. The whole can then be bound round with copper binding wire and solder run into the joint to make it solid. Such a connection is always secure and reliable, and it can be undone in a moment at any time if necessary. It is cheaply and quickly made, and gives a neat and finished appearance to work which it lacks when the straggling ends of stranded conductors are left visible.

A YEAR'S WORK OF THE EQUITABLE TELEPHONE ASSOCIATION.

THOUGH the Equitable Telephone Association has only just completed the first year of its existence, quite a large number of the Swinton telephones are now in use. Among others to whom instruments have been supplied are the following :—Her Majesty the Queen, at Osborne; The Right Hon. Earl Beauchamp, Madresfield Court; The Right Hon. The Earl of Hopetoun, Hopetoun; The Right Hon. Lord Armstrong, C.B., F.R.S., Craigside, and at Jesmond; Sir George Macpherson Grant, The Castle, Ballindalloch; Sir Charles Forbes, Queen's Gate Terrace; Sir William Lewis, Cardiff; The Hon. G. W. Winn, Nostell Priory; Captain Noble, C.B., F.R.S., Newcastle-on-Tyne; The Highland Railway Company; The North British Railway Company; The Gloster Wagon Company, Limited; The Bute Docks Company, Limited; Messrs. Sir W. G. Armstrong and Mitchell and Company, Limited, at Newcastle-on-Tyne, and at Ridsdale; Messrs. Tancred, Arral and Company, Forth Bridge Works; The Co-operative Wholesale Society, Limited; The Pendleton Co-operative Wholesale Society, Limited; Messrs. Gilbert and Rivington, Limited, London; Messrs. Henderson and Company, Limited, Durham; The Birtley Iron Work Company, Limited; The Durham County Asylum; The Rawtenstall Local Board; The Haslingden Local Board; *The South Wales Daily News*.

The Association is at present engaged in fitting up the Hospital for Consumptives at Ventnor, and the offices of the Wholesale Co-operative Society, Limited, Leman Street, E., the former with 11, and the latter with 27 instruments.

Since the Swinton telephone was first described in the ELECTRICAL REVIEW for June 10th, 1887, several modifications have been introduced in the form of the instrument.

One of these—a cheap form of telephone suitable for use as a substitute for speaking tubes and mechanical telephones over short distances—was placed on the market in October last, and has met with a great measure of success.

It will be remembered that the original instruments worked with direct battery currents without induction coils. This arrangement, though it answers very well for short distances, has several disadvantages where the resistance of the line is considerable, and the Association has therefore recently brought out a modified instrument for long distance, in which induction coils are employed. Messrs. Sir W. A. Armstrong, Mitchell and Company, of Elswick, have had a pair of these new instruments working on a three mile line of iron wire for some time, and report that they are giving satisfaction.

THE READING OF DIAL INSTRUMENTS.

THERE is in existence a large number of dial instruments, such as galvanometers, compasses, in which the needle is at some distance from the scale of graduation. It not unfrequently happens that the reading is falsified several degrees through the eye not being in the correct position.

To obviate this serious defect, some makers are in the habit of placing under the needle a flat mirror parallel to the dial. Then the eye is in the correct position when the reflection is hidden by the needle.

When the instruments are not furnished with this excellent arrangement it is still possible to obtain as accurate readings in a simple manner.

The greater number of these instruments have their dial plate covered with a flat glass which is parallel to it. It is sufficient, writes M. F. Drouin in the last issue of *La Lumière Electrique*, to apply to this glass in front of the needle a parallelopiped of plate or flint glass. In virtue of the elementary laws of refraction, the needle will seem to be broken whenever the luminous ray is not normal to the dial. The accuracy of the reading will depend on the thickness of the parallelopiped employed.

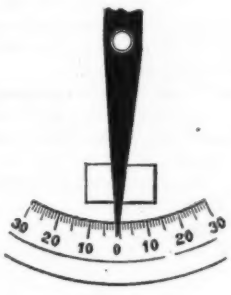


FIG. 1.

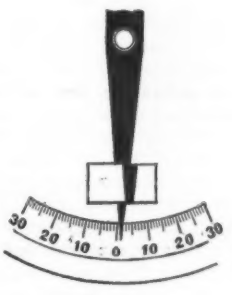


FIG. 2.

Fig. 1 shows the appearance of the needle when the eye is in the correct position, fig. 2 when it is not.

It is evident that the same method may be applied to barometers, thermometers, &c., and, in short, to all instruments in which the index is at a certain distance from the scale of graduation.

A TALK ABOUT THE TELEPHONE IN SHEFFIELD.

THE telephone, like the proverbial woman's tongue, is never still. It is always talking, and talks to some purpose. In Sheffield it began holding haphazard communication with various firms as far back as nine years ago, and now it is whispering all over the town, conveying important business messages, sending from one end of the borough to the other the prices of stock, quotations of iron and steel, all kinds of messages from gossip about last night's dance at Ranmoor, to the state of the hardware trade in Spain.

Since the Telephone Exchange first started it has largely increased its circle of friends. It talks to nearly 500 subscribers; conducts a greater part of their business, is a labour-saver, a counsellor, and with its far-reaching, ever-ready voice, renders many a journey unnecessary, and is a sure preventive of tired legs, obviating the miles of walking from shop to shop and office to office that used to be a necessity in the old days. How frequently the telephone is used in the town is apparent from the fact that one firm engaged in the heavy Sheffield trades (in forging and rolling) during Christmas week had no fewer than 714 conversations through their number. In that week, the heaviest on record in the history of the Sheffield Telephone Exchange Company, the number of messages sent through the Exchange was 49,346. There has, indeed, been a steady increase on the previous year's work of 717,632 messages, the total number sent in 1887 being 1,747,936, compared with 1,030,304 messages in 1886. This telephonic communication is supplied by private enterprise, the Sheffield Telephone Exchange Company being a private concern, an undertaking altogether apart from the National Telephone Company. It has 120 private wires and 13 call offices. The great Sheffield works, the business houses, the Corporation offices, the depôt of the Fire Brigade, the police stations, the medical institutions, the hospitals, the newspaper offices (in one of which, by the bye, a trial with the electric light is about to be made); nearly all the important buildings in the town are connected. The telephone goes to Rotherham (where a local central office has been opened), to Barnsley, to Mexbro, and other places in the Yorkshire coal district; and this development alone has been of immense advantage to the coal trade of the locality, Sheffield being one of the greatest coal marts in the north of England. Altogether the company has about 600 miles of wire, copper wire in preference to galvanised iron wire, as it can be more easily grouped, and is more durable. Among the private exchanges erected by the Sheffield Telephone Company have been three for the Queen, at Windsor, Balmoral and Osborne, one for the Prince of Wales at Sandringham, one at Chatsworth for the Duke of Devonshire, one at Clumber for the Duke of Newcastle, and the Duke of Norfolk has also had an exchange erected.

But to get any idea of the value of the telephone to Sheffield, of the immense help it is to the town's business, one should go into the switch room of the central station in Angel Street. It is one of the finest in the country, with its great board stretching almost from end to end of the room.

No talking is allowed "except on business." But the half-dozen young ladies, on duty, are all talking into as many transmitters. "Central, 268," "Central, central, central!" "Central, 32," "Central, central, 215," "Central—98—engaged," "They won't answer!" Such are some of the phrases I hear. The talk goes on all day and all night. The attendants seem to be speaking with everybody in the town, and there is such dropping of indicators, such deft movement of wires, and rapid communication, that one is surprised not only at the celerity of the telephone in transmitting the message, but the aptitude and dexterity of the staff. To guard against the loss of a moment's time the company has issued to subscribers these instructions: "When you have called the central office, put the telephone to the ear at once, and do not wait for the bell to ring; tell the central office plainly the number of the subscriber you want; keep the telephone to the ear until you are in connection with the subscriber wanted, or until the central office gives you a reason why you cannot be connected; whenever your bell rings *attend to it immediately;* do not turn the handle, but take the telephone off the hook and speak to the subscriber who will be waiting for you with the telephone to his ear." No time is lost in calling subscribers; if a subscriber does not attend when his bell has been rung twice, the switch clerk informs the person who has called that he does not or will not attend, and then answers the next subscriber. So quickly is the thing done that only 10 seconds elapse in a subscriber calling the Central and commencing conversation with another subscriber. The multiple board is fitted with the most modern and improved switching apparatus, and has a capacity for 1,000 subscribers. The incoming wires are terminated on a testing board (provided with lightning arresters) by its side, so that any fault may be easily discovered and remedied. But for the spectator the switchboard itself is the most interesting. There is none of the old monotonous cry, "Are you there?" Nobody's name yelled along the wire. Every subscriber has a distinctive number. He calls the switch room. The indicator drops. The attendant attaches the telephone to the wire, the indicator of which has just fallen. All she says is "Central!" Then the subscriber gives the number of the person with whom he wishes to communicate. The attendant repeats the number for accuracy's sake. This accounts for the mystic language of the switch room. "Central 99." "Central—Central—8. No. 8 is engaged," and so on. Say "Central—55." The attendant places the wire in connection with No. 55, rings his bell, and the subscriber answers "Yes," or "What is it?" The moment the girl hears his voice the central office is shut out of the conversation by a further switch arrangement; and the act of shutting out the central office telephone has, at the same time, switched in a special indicator, which falls when the subscriber signals that he has finished conversation.

The methodical rapidity of the work is admirable; and it is not too much to say that Sheffield owes much of its business prosperity, not only to the scientific and mechanical apparatus in this switch room, but to the active brains and nimble fingers and never-tired voices of the young ladies who so cleverly control and use it.

ELECTRIC LIGHTING IN TAUNTON.

AT the monthly meeting of the Taunton Town Council on Tuesday last week, under the presidency of the Mayor (Mr. S. Farrant), the Finance Committee presented accounts which had been examined by the several committees and recommended by them for payment.

Mr. BRUFORD asked what proportion of the money was for electric lighting?

Mr. CHAPMAN said the amount asked for on that account was £217 10s., for four months.

Mr. BRUFORD: I should like to ask what amount will then have been paid to the electric lighting company to the 31st December.

The TOWN CLERK: £652 10s.

Mr. BRUFORD said that if that was the case he must object to the cheque being paid that day. He had looked through the book and found that the number of hours the light had been on—he would not say anything in regard to its brilliancy—had been 1,902 less than had been contracted for, or close upon 33 days at 8 hours a day they had never any electric light at all.

Mr. VAN TRUMP said that matter would come up in the report of the Lighting Committee.

Mr. BRUFORD said that would be of little use after the cheque was passed. He was strongly opposed to paying the sum of £60 for what they had not received at all, and he would move that the cheque be reduced by the sum of £60. He would not say anything about the brilliancy of the light, that was another matter, but the hours at which the light had not been on should be deducted.

Mr. WEBBER said that if Mr. Bruford would allow this matter to stand over till the Lighting Committee's report had come on he should be pleased to second his resolution with the understanding that the Council should have an opportunity of voting upon it, and that the cheque be kept back.

Mr. BRUFORD: I have no objection to that.

Mr. STANDFAST was quite agreeable to that course if the payment of the cheque was allowed to stand over until the Lighting Committee had reported. What Mr. Bruford had said was most reasonable, and unless some different light was thrown upon it by the Lighting Committee he should have much pleasure in supporting what he had proposed.

At a later period of the meeting, the Watch, Lighting and General Purposes Committee reported that the electric lighting had been 1,902 hours less than the contract. The extra hours would be carried on to the present year.

Mr. VAN TRUMP moved the adoption of the report, and on the electric lighting question, mentioned that the Council accepted the tender of the company for an eight hours' supply daily, although the committee had only recommended that it should be six hours. It had since been found that seven hours would be

ample, and they had communicated with the electrician, who had agreed to carry forward the number of hours' lighting not required to the end of the contract.

Mr. WEBBER seconded, and maintained that the blame rested upon those members of the Council who first opposed the scheme, and then adopted the eight hours' system. It was now found that six hours would be sufficient, and the committee were unanimous in endeavouring to save a number of hours. The money was not absolutely lost, as at the end of the contract the number of hours saved would be credited to the Council, who would be able to use the light until the quantity saved had been exhausted.

Mr. BRUFORD said they were nearly 2,000 hours short, and this represented £60. It was not honest to the ratepayers to pay for what they had not had. Why should they go on for three years, and how did they know the company would be in existence at the end of that period? He moved that the £60 be deducted from the cheque.

Mr. STANDFAST seconded this, and contended that the light was not reliable, as it went out suddenly sometimes.

Mr. HAWKINS said he did not see that the Council were going to be robbed of the £60. There certainly had been some little complaint as to the light going out, but he thought the gas afforded grounds for complaint also. It was better when the electric light started, but lately it had dropped off.

Mr. SAUNDERS said that it was better than ever it was.

Mr. VILE, Mr. GOODLAND and Mr. CHAPMAN supported the resolution.

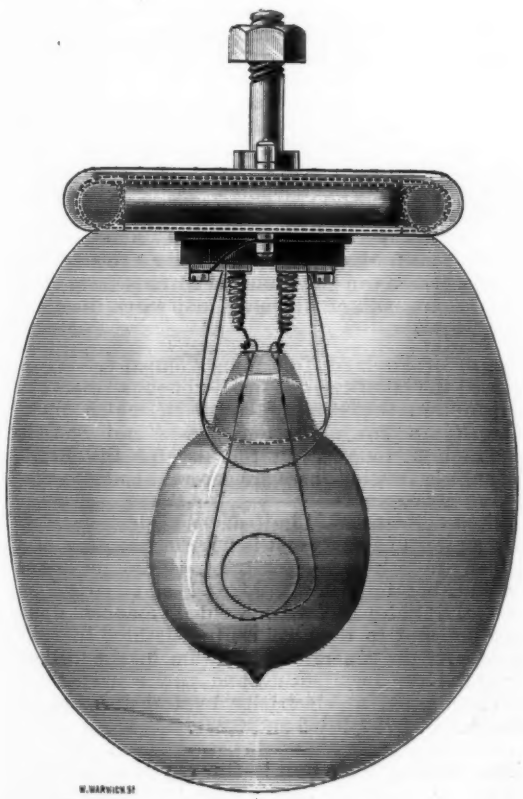
Mr. LOCK said that there was no doubt whatever that the matter would be satisfactorily arranged.

Mr. WICKENDEN moved that the question should stand over until the next meeting. He understood the Electric Light Company had not had the matter before them, and an opportunity should certainly be given them to consider it.

Mr. VILE seconded, and this was agreed to, the cheque for the whole amount being withheld.

INCANDESCENT LAMP FITTINGS.

THE accompanying illustration shows clearly the construction of the storm proof fitting for incandescent lamps designed by Messrs. Sudworth and Falkenstein, which we mentioned last week in reference to the lighting of the British Xylonite Company's factories in



Manningtree. The circular base is of Xylonite or any other suitable material, holding the lamp and lamp holder, over which is fitted the glass globe hermetically sealed by the india-rubber ring. The globe may be taken away by a pressure of the hand on one side of the ring, and as easily replaced. Altogether the apparatus is very simple, and should meet with a considerable application.

SIR WILLIAM THOMSON'S PAPER "ON THE APPLICATION OF THE DECI-AMPERE OR CENTI-AMPERE BALANCE TO THE DETERMINATION OF THE ELECTROMOTIVE FORCES OF VOLTAIC CELLS."

ON account of the numerical error in this paper (see ELECTRICAL REVIEW for December 9th, 1887), pointed out by Mr. Desmond Fitzgerald in a communication to the *Electrical Engineer* for January 6th, 1888, referring to Mr. Gray's measurement of November of the electromotive forces of Clark cells constructed by Mr. Bottomley last March, substitute for the last four lines of the article, "correcting to 15° C., we obtain 1·4346 Rayleigh volts at that temperature. This result is interesting, as showing a difference of less than $\frac{1}{30}$th per cent. from that obtained by Lord Rayleigh for similar cells, which was 1·435 at 15° C."

NOTES.

Electric Light in a Dundee Carpet Factory.—The new carpet factory at Lawside, Dundee, which has been erected for Messrs. James Paterson & Co., has been fitted with the electric light by Messrs. Lowdon, Reform Street. About 500 lamps are employed, and the preliminary tests have proved highly satisfactory. Besides being covered with India-rubber, the wires are encased with wood and fitted with safety fuses. The dynamo is one of Mather and Platt's, and is worked by the engine which drives the looms. It is anticipated that the light will be cheaper as well as better than gas.

Electric Light in Weaving Sheds.—The weaving shed of Mr. A. Wilson, of Calder Vale, Todmorden, is now lighted by electricity, and the experiment is reported to be very successful. The hands speak very favourably of the new light, and prefer it to gas.

Electric Lighting in Northampton.—Messrs. Westley and Son have had their extensive premises at Nunn Mills, Northampton, fitted with the Crompton system of electric lighting. The mills were on Wednesday last week for the first time fully illuminated with the new light.

Balloons and Electric Signalling.—Incandescent lamps are to be taken into Abyssinia as an accompaniment to the military balloons of the Italian army, and are to be used for signalling at night. They are to be placed outside the balloons and in front of reflectors. Telephones for verbal communication between the cars and the ground are also to be taken.

Football under Electric Light.—The Halifax Football Club has had its grounds permanently illuminated by the electric light. The field is surrounded with high masts, from which powerful arc lamps are suspended. Football matches are being arranged to take place on week-day evenings with the leading Rugby clubs.

The Electric Light at Bicester.—The electric light has been introduced at the Garth, Bicester, the residence of Mr. E. A. Brocklehurst. The work has been carried out by Mr. F. Amos, electric engineer, of Bicester, and so far the experiment has proved a success. There is every probability of a further substitution of this means of lighting for gas in Bicester.

Electric Lighting in the Metropolis.—At a meeting last week of the St. George's vestry, it was resolved, upon the recommendation of the Roads Committee, "that the application of the Anglo-American Brush Electric Light Corporation, Limited, for permission to lay electrical conductors under the footway on the west side of the Blackfriars Road, according to plans to be approved by the vestry, and offering to supply the electric light to the inhabitants of the Blackfriars Road upon the same terms as the current is supplied elsewhere by the company, be granted upon condition that the company enter into an agreement to be prepared by the vestry's solicitor, all costs and charges of such agreement to be paid by the company; that, before breaking up the pavement, notice be given to the vestry, and the reinstating of the pavement be done to the satisfaction of the vestry's surveyor; that a nominal rent of 5s. per annum be paid to the vestry by the said company, and that all expenses of, and incident to, the carrying out of the above from time to time be paid by the said company, and the contract be terminable by six months' notice on either side."

Bath and the Electric Light.—At the last meeting of the Bath Electric Lighting Committee the town clerk was instructed to communicate with the authorities of the various towns and cities of England with the view of obtaining information as to what course of action they were taking in the matter of electric lighting.

Navigation by Electric Light.—The *Times* Paris correspondent states that 63 vessels passed through the Suez Canal in November with the aid of the electric light.

Canterbury and the Electric Light.—The Canterbury Town Council seems to be strongly in favour of lighting the town by electricity. The proposal is that the Thomson-Houston system shall be adopted. Mr. O'Hagan has promised to supply the Town Council with the necessary details, and will bring them up at the next Council meeting, when it is expected a definite decision will be arrived at.

Weston-super-Mare and the Electric Light.—The monthly meeting of the Town Commissioners of Weston-super-Mare was held on Wednesday last week. The Highway Committee reported the receipt of several tenders to light the town with electricity, but the inquiries had not been completed, and the committee therefore postponed their report.

Shop Lighting.—Messrs. Rowntree, Hills & Co., of York, have recently adopted the electric light in their shops. The installation, which has been carried out by Messrs. J. H. Holmes & Co., Newcastle-on-Tyne, consists of a No. 8 "Castle" dynamo (compound wound), giving 70 ampères, 60 volts, at a speed of 1,000 revolutions, driven by a 6 H.P. "Stockport" gas engine. The shops are lighted by nine of J. H. Holmes's patent "Castle" arc lamps, which received a silver medal—the highest award—at the Newcastle Exhibition, and five small ones giving 400 candle-power, with a current of five ampères. The offices at the back of the premises are lighted with 60-volt Swan lamps. The arc lamps employed in this installation are of Messrs. Holmes & Co.'s new and improved type, including their recently patented arrangements for ensuring a definite feed, and thus regulating the lamps with great certainty. The creamery is elaborately panelled with decorated tiles, and the small arcs in this department give a charming effect.

Electric Lighting Methods.—Mr. W. Lynd is determined that Bournemouth, if it decides to adopt the electric light, shall not do so in ignorance of the most approved methods of effecting the illumination. In an article of some length which he has just contributed to the local paper he tersely states the characteristics of the direct lighting, alternate current and storage battery systems, and sums up forcibly in favour of the introduction of accumulators.

Theatre Lighting.—The Thomson-Houston Company has bought ground in the Champ de Mars at Brussels for the installation of steam engines and dynamos for lighting the Théâtre Molière. The Théâtre Café, the Porte de Namur, and part of the Chaussée de Wavre are also to be lighted.

Trunk Lines from London.—We understand that an agreement has been arrived at between the United and the National Telephone Companies, whereby the Metropolis will shortly be placed within speaking distance of the Midland districts, and ultimately also with the North of England. A heavy copper line will at once be laid to Coventry, and from there it is intended to fork to the left to Birmingham, and thence to Liverpool and Manchester, and to the right to Nottingham, Sheffield, and Leeds. The details are not yet, however, fully decided upon; but it may be anticipated that the line will be open to Birmingham within a few months from the present time.

The Telephone in Newport.—As an experiment, the Western Counties and South Wales Telephone Company has opened a call room at Alexandra Dock Pierhead in connection with the Newport (Monmouth) Exchange system.

The Telephone in Cumberland.—On Monday night last week, the Mayor of Carlisle publicly opened the National Telephone Company's trunk line between Carlisle and Maryport, which now completes telephonic connection between the county town and Whitehaven. From Maryport to Workington there are two trunk wires, and from the latter place to Whitehaven three. The new line from Carlisle has been anticipated for some time, but it was only within the last two months that its actual construction was undertaken, and finished under the superintendence of Mr. F. F. Bennett, manager of the National Telephone Company in Cumberland, ably assisted by Mr. Jamieson, district manager, Carlisle. By its completion, the whole of the West Cumberland system, including Maryport, Workington, Whitehaven, Cleator Moor, Frizington, Cockermouth, and Parton are brought into direct communication with the county town. The new line runs through Wigton, Aspatria, and on to Maryport. It is now three years since the telephone was introduced into the west of Cumberland, and since then between 400 and 500 miles of wires have been opened out. In the two years that the telephone has been in existence in Carlisle there has been 61 miles of wires erected. In the west of the county the subscribers number about 250, and in Carlisle 57. The longest distance over which a person can speak on the wires is from Dalston to Egremont, both of which are loop wires, the distance being 54 miles.

South of England Telephone Company.—We have received the latest issue of the list of subscribers of this company, in the Brighton district, which includes Hove, Kemp Town, Preston, Lewes and Shoreham. The highest number on the list for the Brighton exchange is 760, but there are several blanks.

Shippey Brothers, Limited.—We are requested by the manager to state that it is not the intention of this company to manufacture or sell incandescent lamps in England, but to manufacture and sell electrical apparatus, the Shippey-Wyder welded magnet dynamo machines, and to establish central stations in colliery districts for the generating of steam by the utilisation of natural gas for lighting and power purposes, and the distribution of electricity by transformers under patents Nos. 1,752, 9,365 and 6,221.

That Electropathic Belt!—Our experiments with the belt sent to us by "A Poor Victim," being not yet completed, we must defer our comments thereon.

Postponement of Sale.—The sale of the Tufnell Park Mills Company, which was announced for the 27th inst., is postponed until further notice.

Snow and the Wires.—Snowstorms caused an interruption of the telegraphic service in Greece at the beginning of the week.

Storage Batteries for Telegraphic Purposes.—The Exchange Telegraph Company has for six months past employed storage batteries to work the Stock Exchange "tapes" from its office in Cornhill. Two thousand primary batteries were formerly required, but the work is now adequately performed by 210 "E.P.S." accumulators, arranged in three series of 70 each. Mr. Higgins, engineer of the Exchange Company, says:—"About 72 per cent. of the electric energy supplied to the accumulators by a dynamo is returned to work the 'tapes.' This current is much steadier than that obtained from primary batteries, and shows no perceptible variation from day to day. The time necessary for charging may from the number of words transmitted be calculated to within a few minutes daily." This satisfactory application of "E.P.S." accumulators should lead to its being very largely adopted for telephonic and telegraphic purposes.

The Electro-Harmonic Society.—The programme of the third Concert of the second season of this Society, which takes place next Friday, can be seen on page 5 of our Supplement. With the exception of Messrs. Coward and Tufnail, who are, however, well known in the musical profession, the artistes are familiar to the members, and a most enjoyable evening may be anticipated. The items being fewer than hitherto, it follows that the intervals may be made somewhat longer, and this will prove a boon to those who most desire to converse.

Kennedy's Dynamo.—Messrs. W. T. Goolden & Co. write:—"With reference to your description of the Kennedy dynamo, we beg to say that we have made a number of small machines of almost identical design, the first of this type being made in September, 1885. We beg to enclose side and end elevations of this type of machine." As in the case of Messrs. Royce & Co., whose letter we published last week, the drawings sent show a great similarity to those of Mr. Kennedy.

The Society of Telegraph-Engineers and Electricians.—The next meeting will take place at the Institution of Civil Engineers 25, Great George Street, S.W., on Thursday, January 26th, when the discussion on Mr. Arthur C. Cockburn's paper "On safety fuses for electric light circuits, and on the behaviour of the various metals usually employed in their construction," will be continued.

Personal.—Mr. Andrew Bell, who has recently retired from the Postal Telegraph Service, in which he has been superintendent of the Gloucester Road Factory since the transfer of the Telegraphs to the State in 1870, has been presented with a timepiece and microscope by a number of his colleagues as a mark of their respect and esteem.

Electrical Litigation.—Electricity may perhaps be applied beneficially so far as regards health, but it certainly does not seem to have a soothing effect when employed for industrial purposes, as witness the enormous amount of litigation now proceeding in America. There hardly appears to exist a company or corporation engaged in electrical pursuits that is not either prosecutor or defendant in one or more causes.

Electricity on Railways.—Negotiations with the Electric Traction Company have enabled the directors of the Metropolitan Railway to conclude an arrangement whereby that company has undertaken to construct, at its own expense, for experimental running upon a section of the railway outside the circle, an electric locomotive of the same power as the Metropolitan Company's present locomotive, the directors giving them the necessary facilities for such experimental working.

An Electrical Chess Recorder.—A very ingenious application of electricity in connection with the game of chess has been invented by Dr. Wurstemberger, of Zurich. It consists of an apparatus for recording every move, similar to the ordinary tape instruments, and is placed in electrical connection with the chess board. Each of the chess pieces has a small peg at the bottom, which is inserted in a hole in the centre of each square of the board. The pegs of the black pieces are metallic, while those of the white pieces are of an insulating material, and this causes the printing on the tape to show whether the record relates to a white or a black piece. The recorder practically consists of a small motor driving a printing wheel. By this ingenious contrivance an absolute record of every move of a game is preserved, as was shown on our recent inspection of the apparatus at the offices of the Woodhouse and Rawson Company, 11, Queen Victoria Street, London.

Lecture.—Mr. G. J. Snelus, manager of the West Cumberland Iron and Steel Works, recently delivered a lecture on electric lighting at Workington.

Electricity and Pathology.—Dr. C. B. Radcliffe, F.R.C.P., writes in the *Lancet* on "The Electrical Basis of Vital Motion."

Philosophical Society of Glasgow.—At the meeting of the Philosophical Society of Glasgow on Wednesday night last week, Mr. William Bottomley, C.E. first read a paper on "The Heeling Error of the Compass in Ships."

American Electric Railways.—The extension of electric railway systems has progressed very rapidly, but with this progress the quality and workmanship of the materials and appliances employed has steadily deteriorated, the great desideratum being apparently to be first in the field.

Sunstroke by Electricity.—In the *Journal des Débats*, M. Henri de Parville gives an account of some extraordinary medical observations on electric sunstroke collected at the famous French foundry, Creuzot, by the medical officer-in-chief there, Dr. Defontaine, and communicated by him to the Surgical Society in Paris. Creuzot has for some time possessed its electric furnace. Steel is soldered directly by the high temperature produced by electricity. The electric arc in which the metal is placed is of great power. It almost always happens that, after an hour or two, persons witnessing the experiments feel a burning sensation, with more or less pain, in the neck, face, and forehead, and their skin at the same time assumes a coppery-red tint. It is customary to protect spectators' eyes with blackened sun-glasses; yet their retina is affected to such an extent that blindness supervenes in broad daylight for several minutes, and for nearly an hour all objects are seen in deep saffron colour. The lachrymal glands suffer excessive stimulation, and tears flow. Other symptoms are headache and sleeplessness. Afterwards the skin of the face gradually peels off in broad flakes, when the complexion is left of a fine brick colour. All the heat seems to remain concentrated; but while at five yards' distance the thermometer hardly moves, bystanders suffer stroke even at fourteen yards.

Blasting Operations.—On Saturday afternoon very extensive blasting operations were carried out at Goldmire, a limestone quarry about three miles from Barrow, the property of the Askam and Mouzell Iron Company. A hole 40 feet long was driven into the face of the rock, and 126 feet from the surface. A chamber was here formed somewhat in the shape of a decanter or bottle, and into this nearly 4 tons of coarse blasting powder was placed. An electric fuse was placed in the hole, there was a tremendous report, and the whole face of the rock was brought down, crumbling into comparatively small pieces. It was estimated that about 40,000 tons of rock had been dislodged.

Panic in a Theatre.—Shortly after the performance of "Ali Baba" had commenced at the Alhambra Theatre, Brussels, on Monday evening, flames were observed to be proceeding from a stove used for heating the auditorium. A panic seized the occupants of the pit, who rushed to the exits in their endeavours to escape. The firemen soon succeeded in mastering the flames, and the performance then proceeded.

New York Electric Club.—Professor H. A. Rowland, of John Hopkins University, is to deliver the address at the formal opening of the New York Electric Club, which will take place on Tuesday evening, the 31st inst. We have to thank Mr. Charles W. Price, the secretary, for a cordial invitation to the celebration, and to regret that pressure of business and other things prevent our attendance. Some other time, perhaps!

Fire Alarms and Lightning Conductors.—Messrs. Cox-Walker & Co. have received an order from the City of London Lunatic Asylum for one of their "silver medal" electric tell-tales for thirty stations, and for all the necessary apparatus, wire and other work connected therewith. The firm is also at present engaged in wiring the County Lunatic Asylum at Whittingham, near Preston, for two of their "silver medal" tell-tales, fire alarms, and other apparatus, and is erecting on the tower of the new Town Hall at Middlesbrough one of the largest and longest lightning conductors in the district. This conductor is one of Vyle's patent easily tested description.

Electrician's Directory.—The sixth annual edition of this year-book has just been issued from the office of *The Electrician*. It contains useful tables relating to dynamos, arc and incandescent lamps, batteries, &c., a carefully compiled list of home, colonial and foreign electricians, electrical engineers, electric light engineers and contractors, electrical apparatus makers, electric bell makers and fitters, telegraph and telephone companies, telegraph and telephone engineers, wire makers and drawers, &c., &c., &c.; and also an increased biographical section, giving interesting particulars concerning eminent men connected with electricity in all its applications, with portraits, in some cases of doubtful value as a method of recognition. The work, on the whole, is an excellent one.

A New Lacquer.—Under the name of ardenbrite, a new lacquer has recently been introduced by the Ardenbrite Manufacturing Company, of 70, Southampton Row, Holborn. It is claimed that the new lacquer is so fine that it is invisible on the most delicate instruments, and so strong that it stands weather, steam, smoke, sea air, and sea water; gold, silver, copper, steel, brass, and iron, are said never to tarnish when coated with it; moreover it dries hard in half an hour in or out of doors, *without heat*. We have had the ardenbrite tried by a competent authority, and the result has been quite satisfactory. We can, therefore recommend it as being a valuable acquisition for workshop purposes.

American Gas Companies.—Gas companies in the States seem fully alive to the fact that in the electric light they have to meet a very powerful competitor. It is consequently not surprising to learn that many of these companies, in order to keep control of the lighting, are laying down electric light installations so as to supply their customers with either form of lighting.

The General Post Office.—Mr. J. H. Clutton has awarded the trustees of the French Protestant Church £25,916 in settlement of their claims for the compulsory acquisition by the Post Office of the church and grounds, occupying some 3,831 square feet. The Governors of Christ's Hospital have been awarded £129,937, the Great Northern Railway Company £31,350, and Messrs. King and Gillespie £18,000 and £10,000 respectively.

Reckenzaun Electric Cars.—These cars are gaining great favour in the States and are giving good results when subjected to severe tests. One recently ran 63 miles with one charging of the batteries. In this run there were 331 curves of 33 feet radius, 662 curves of 50 feet radius and 331 curves of 100 feet radius. Mr. Wm. Wharton, jun., president of the Electric Car Company of America, challenges Mr. Mailloux to a test of the relative powers of the Julien car, in which the latter is interested, and the Reckenzaun car. For every mile Mr. Mailloux's car runs more than the Reckenzaun, Mr. Wharton offers to pay $100, provided Mr. Mailloux will agree to pay $50 for every mile he may be beaten by.

Bare Wires.—An example of the dangers attending the use of bare wires for electric lighting occurred recently in South Boston. By one of those mischances, which might occur at any moment, a telephone line was crossed with an electric light wire, the result being destructive fires in the offices of three subscribers.

NEW COMPANY REGISTERED.

Willans and Robinson, Limited.—Capital £200,000, in £50 shares. Objects: To take over the business of Messrs. Willans and Robinson of Thames Ditton, mechanical and electrical engineers, launch and shipbuilders. Signatories (with 1 share each): *P. W. Willans, Frimley Lock, Surrey; *Mark H. Robinson, Surbiton; *Sir Gilbert Clayton East, Bart., Maidenhead; E. L. Scott, Salter's Hall, St. Swithin's Lane; G. D. Douglas, Thames Ditton; J. C. Peache, Thames Ditton; P. A. Low, Long Ditton. The first three subscribers are appointed members of the board of managers: Qualification, 50 shares: Remuneration, £1,200 per annum, with a further £200 for each additional £10,000 paid up capital beyond £100,000. Registered 12th inst. by Farrar and Farrar, Doctor's Commons.

House to House Electric Supply Company, Limited.—Capital £350,000, in £5 shares. Objects: To form centres at which electric power may be generated or accumulated, and from which the same may be distributed for lighting purposes. Signatories (with 1 share each), Robert Hammond, 117, Bishopsgate Street, E.C.; J. Whitehead, Crouch End, N.; W. Capel Slaughter, 18, Austin Friars; F. W. Bentley, 117, Bishopsgate Street, E.C.; C. E. Hadcock, Shooter's Hill; H. St. John Winkworth, 11, Harrington Road, S.W.; W. May, 18, Austin Friars. The subscribers appoint the first directors. Qualification: 100 shares, or £500 stock. Remuneration: £1,000 per annum. Registered 16th inst. by W. C. Slaughter, 18, Austin Friars, E.C.

The company will adopt an agreement under which Mr. Robt. Hammond will receive £5,000 in ordinary shares, and 100 fully paid shares, as payment for certain considerations referred to therein, but of which no particulars are given in the registered documents.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

W. T. Henley's Electric Light and Power Company, Limited.—The annual return of this company, made up to the 7th inst., was filed on the 14th inst. The nominal capital is £100,000 in £1 shares. 6,918 shares are allotted and the full amount has been called thereon. The calls paid amount to £6,911 and unpaid to £7. The sum of £41 10s. 11d. has been paid upon 101 shares forfeited.

Oppermann Electric Lighting and Manufacturing Company, Limited.—At extraordinary general meet-

ings of this company, held on the 22nd ult. and 7th inst., it was proved to the satisfaction of the meeting that it is advisable to wind up the company, and it was therefore resolved that the company be wound up voluntarily, and that Mr. Hugh Nigel Warburton, of Shipton-under-Wychwood, Chipping Norton, be appointed liquidator.

Sir Coutts Lindsay and Company, Limited.—The annual return of this company, made up to the 3rd inst., was filed on the 10th inst. The nominal capital is £200,000 in £1 shares. 79,500 shares have been allotted and the full amount has been called thereon. The calls paid amount to £74,859 10s. and unpaid to £4,640 10s.

At an extraordinary general meeting of the members of the company held at 79, Grosvenor Street on the 19th ult., the following special resolutions were passed, and at a subsequent meeting on the 6th inst. were confirmed, and were registered on the 12th ult., viz. :—I. That the agreement the sale of all the company's property and undertaking, dated December 2nd, 1887, and made between Sir Coutts Lindsay & Co., Limited, and the London Electric Supply Corporation, be and is hereby confirmed. II. That the company be wound up voluntarily and that a liquidator be appointed for the purpose of such winding up.

Chatham, Rochester, and District Electric Lighting Company, Limited.—The registered office of this company is now situated at Victualling Office Wharf, Rochester.

Kensington Court Electric Lighting Company, Limited.—The annual return of this company, made up to the 5th inst., was filed on the 12th inst. The nominal capital is £10,000 in £5 shares. 965 shares are taken up and £5 per share has been called thereupon. The amount of the calls paid is £4,825.

CITY NOTES, REPORTS, MEETINGS, &c.

The Direct United States Cable Company, Limited.

THE report of the directors for the six months ended 31st December, 1887, to be presented at the 21st ordinary general meeting of the company, at Winchester House, 50, Old Broad Street, to-day, states that the revenue for the half-year (subject to revision on settlement with the French Company), after deducting out-payments amounted to £23,002 17s. 6d. against £19,603 6s. 11d. (after similar deductions) for the corresponding period of 1886, being a difference of £3,399 10s. 7d. in favour of the half-year under review.

The working and other expenses for the same period, including income tax, &c., amounted to £15,864 18s., leaving a balance of £7,137 19s. 6d. as the net profit of the half-year, making with £5,004 0s. 6d. transferred from the reserve fund account a total of £12,142. For the corresponding half-year of 1886 the working expenses and other payments amounted to £16,354 7s. 6d.

Interim dividends of 2s. per share each for the quarter ended 30th September, 1887 (paid 24th October, 1887), and for the quarter ended 31st December, 1887 (payable 24th January, 1888), together amounting to £12,142, have been declared.

After mature consideration by the board, the company's cables and station were removed, during October and November last, from Torbay to Halifax (N.S.), and that portion of the short cable which lay across "Brown's Bank" was taken up and relaid in deeper water to the southward of the Bank. 101 knots of new cable were required for carrying out these operations which were successfully performed by the Telegraph Construction and Maintenance Company with their ss. *Britannia*.

By the changes thus made it is expected that the interests of the company will be largely benefited, and that the costly interruptions, formerly so frequent, will probably now be avoided.

The cost of the whole work, including charter of the ship, and cable expended, amounted to £22,827 5s. 10d.

The test action brought by the Anglo-American Telegraph Company against La Compagnie Francaisé du Télégraphe de Paris à New York, to enforce performance of the joint purse agreements, was heard before the Paris Tribunal of Commerce on the 12th ultimo. The directors have the satisfaction of being able to report that the decision of the Paris Tribunal was delivered on the 9th instant, adjudging the French Company to perform the joint purse agreements, and condemning that company to pay 2,000 francs per day from the 1st January, 1887 (estimated at £30,000), as damages for past breaches, and further mulcting it in the costs of the action.

With a view of affording additional facilities to the public, a joint (branch) office has been established by the Associated Companies at Broome Street, New York.

The sixpenny tariff continues but the progressive development in the traffic has not been maintained.

The directors record with deep regret the loss they have sustained by the death of Lord Hawke, which occurred suddenly on 5th December last. Lord Hawke had been a director of the company from the date of its reconstruction in 1877. The vacant seat at the board has not been filled up.

The engagement of Mr. J. W. Fuller, late Secretary and Traffic Manager, has been terminated in consequence of severe illness, to the great regret of the board.

The Eastern Telegraph Company, Limited.

THE thirty-first half-yearly ordinary general meeting was held at Winchester House, Old Broad Street, yesterday (Thursday), Sir John Pender, K.C.M.G., presiding.

Mr. Geo. Draper, the Secretary, having read the notice convening the meeting, the following report for the half-year ended 30th September, 1887, was taken as read :—The revenue for the period amounted to £291,265 13s. 3d., from which are deducted £79,936 11s. 4d. for the ordinary expenses, and £34,102 5s. 7d. for expenditure relating to repairs and renewals of cables, &c., during the half-year. After providing £4,465 4s. 8d. for income tax, there remains a balance of £172,761 11s. 8d., to which is added £559 3s. 2d. brought from the preceding half year, making a total available balance of £173,320 14s. 10d. From this balance there have been paid :—

	£	s.	d.
Interest on debentures and debenture stock	28,538	4	9
Dividend on preference shares	20,384	13	8
Two interim dividends of 1¼ per cent. each on ordinary shares	95,000	0	0
	£143,922	18	5

Leaving a balance of £29,397 16s. 5d., which is carried forward to the next account. The revenue includes £15,600 dividend for the half year upon the company's shares in the Eastern and South African Telegraph Company, and also £384 4s. 5d. net receipts for the half year on the shares of the Black Sea Telegraph Company belonging to this company. The cables of these companies are in good working order. With some exceptions, the several sections of the company's cables and land lines continue in good working order; but, as the company's system is duplicated, and in some places triplicated, the interruptions do not affect the revenue. The new cable from Porthcurnow to Lisbon, Gibraltar, Malta, and Zante, referred to at the last meeting, was successfully laid by the contractors, the Telegraph Construction and Maintenance Company, and opened for traffic in October last. The new cable steamer *Amber*, built by Messrs. Napier and Sons, Glasgow, to replace the ss. *Volta*, has been launched, and will shortly be ready for service. The directors have satisfactorily completed the issue of 4 per cent. mortgage debenture stock to replace the £450,000 5 per cent. debentures which fell due on 1st August last.

The Chairman moved the adoption of the report and accounts. The Marquis of Tweeddale seconded, and the motion was carried unanimously, together with a rider added to it at the instance of Mr. Lindsay Nicholson, in which the shareholders congratulated the chairman upon the honour conferred upon him by the Queen.

The retiring directors, Sir John Pender and the Marquis of Tweeddale, and the auditors, Mr. Henry Dever and Messrs. Quilter, Welton & Co., were re-elected, and the meeting terminated with a vote of thanks to the chairman and his co-directors.

The United Telephone Company, Limited.—The directors have decided to call up the remaining amount payable in respect of their 20,000 new shares of £5 each (numbered 80,001 to 100,000), issued at £2 per share premium—viz., £2 10s. on account of capital, and £1 on account of premium. The call will be payable on the 1st of May next, and the directors are prepared to receive payment in advance; such payment to carry interest at 3½ per cent. per annum until the 30th of April. No transfer will be accepted after the 30th of April unless the call has been duly paid.

The Globe Telegraph Trust Company, Limited.—The directors have declared an interim dividend of 3s. on the preference shares, less income tax, and of 1s. 6d. on the ordinary shares, income tax having already been deducted, for the quarter ending the 18th inst., payable on the 27th inst.

The Eastern Extension, Australasia and China Telegraph Company, Limited.—This company notifies that the interest due February 1st. on its 6 per cent. debentures will be paid on and after that date at the Consolidated Bank, 52 Threadneedle Street. Coupons must be left three clear days for examination.

TRAFFIC RECEIPTS.

The West India and Panama Telegraph Company, Limited. The estimated receipts for the half-month ended the 15th January are £2,509, as compared with £2,976 in the corresponding period of 1887.

PROCEEDINGS OF SOCIETIES.

The Society of Telegraph-Engineers and Electricians.

(*Concluded from page* 48.)

F.—Correction for Temperature.

In what precedes we have disregarded the effect produced by the variation of the temperature of the instrument as a whole, caused partly by variations of atmospheric temperature, and partly by the warming up of the whole instrument by a prolonged maintenance of the potential difference at its terminals. We will now investigate the magnitude of the error so caused.

Let a be the coefficient of expansion of the stretched wire;

β be the coefficient of expansion of the framework supporting the ends of the wire;

y_o be the dip o Q (fig. 10) at the temperature of graduation;

y_t " " $t°$ C. above " " "

y " " $\theta + t°$ C. " " " "

then $$y_o^2 + \text{A Q}^2 = \tfrac{1}{4} l_o^2,$$

$$y_t^2 + \text{A Q}^2 (1 + \beta t)^2 = \tfrac{1}{4} l_o^2 (1 + a t)^2,$$

$$y^2 + \text{A Q}^2 (1 + \beta t)^2 = \tfrac{1}{4} l_o \{1 + a (\theta + t)\}^2;$$

$$\therefore y^2 - y_o^2 = \tfrac{1}{2} l_o^2 a \theta + \tfrac{1}{2} t (l_o^2 a - 4 \text{A Q}^2 \beta).$$

If the initial dip at the temperature of graduation be small,

$$4 \text{A Q}^2 = l_o^2, \text{ approximately;}$$

$$\therefore y^2 - y_o^2 = \tfrac{1}{2} l_o^2 \{a (\theta + t) - \beta t\}.$$

Let $$a - \beta = \gamma,$$

where γ can be made positive, nought, or negative by compensation of the framework of the instrument for changes of temperature. Hence

$$y^2 - y_o^2 = \tfrac{1}{2} l_o^2 (a \theta + \gamma t) \qquad (17)$$

Also, if ρ_o be the specific resistance of the material of which the wire is made at the temperature of the framework of the instrument during graduation; and if ρ be the specific resistance when the framework of the instrument is at a temperature $t°$ C. above that of the temperature of graduation, and when the wire has a temperature $\theta°$ C. above that of the framework,

$$\rho = \rho_o \{1 + k (\theta + t)\}.$$

Consequently, following the reasoning previously given, connecting the rate of loss of heat by radiation and convection, and the rate of production of heat by the passage of the current, we have

$$\theta = \frac{\text{V}^2 d}{4 l_o^2 \varepsilon \rho \{1 + k(\theta + t)\}}, \text{ approximately.}$$

Substituting in (17) the value for y given in (6), and for θ the value just obtained, we have

$$\phi^2 + 2 \frac{s}{r} y_o \phi = \frac{s^2}{r^2} \tfrac{1}{2} l_o^2 \left(a \frac{\text{V}^2 d}{4 l_o^2 \varepsilon \rho_o \{1 + k (\theta + t)\}} + \gamma t \right)$$

$$= \frac{s^2 d a \text{V}^2}{r^2 8 \varepsilon \rho \{1 + k (\theta + t)\}} \left(1 + \frac{\gamma t}{a \theta}\right)$$

$$= \frac{\text{A V}^2}{(1 + k \theta)\left(1 + \frac{k t}{1 + k \theta}\right)} \left(1 + \frac{\gamma t}{a \theta}\right),$$

or $$\phi^2 + 2 \phi_o \phi = \frac{\text{A V}^2}{1 + k \theta}\left(1 - \frac{k t}{1 + k \theta} + \frac{\gamma t}{a \theta}\right), \text{approximately (18)}$$

Now formula (8), obtained on the assumption that the framework of the voltmeter always remained at the temperature it was at during the graduation of the instrument may be written

$$\phi^2 + 2 \phi_o \phi = \frac{\text{A V}^2}{1 + k \theta};$$

hence the effect of the whole instrument being heated up to $t°$ C. is to diminish the right-hand side of the equation by the fraction $\frac{k t}{1 + k \theta}$ of itself, in consequence of the increase of the resistance of the stretched wire; and to increase the right-hand side of the equation by the fraction $\frac{\gamma t}{a \theta}$ of itself, in consequence of the difference of the coefficients of expansion of the stretched wire and the framework. If γ, the difference between the coefficients of expansion of the stretched wire and of the framework, be selected so that

$$\gamma = \frac{a k \theta}{1 + k \theta},$$

then for that particular value of θ there will be no temperature error of the instrument. Now the effect of γ not being nought will be to cause a slight motion of the pointer when the whole instrument is warmed up as a whole without any potential difference being maintained at its terminals; or, in other words, γ produces what may be called a zero error. Hence the zero error can be made such that there is no temperature error when the instrument is required to measure a certain definite potential difference or a potential difference of about that value. If, on the other hand, the framework of the instrument be so constructed that γ is nought—that is, so that there is no zero error—then the deflection corresponding with any given number of volts maintained at its terminals will be somewhat diminished as the instrument warms up as a whole. In order that accurate readings may be able to be made of small potential differences giving deflections near the zero it will be desirable to make γ small, but whether it ought to be made absolutely nought or not can only be determined by practical experience of this new form of voltmeter extending over some time.

Solving (18), we have

$$\phi = -\phi_o + \sqrt{\phi_o^2 + \frac{\text{A V}^2}{1 + k \theta}\left(1 - \frac{k t}{1 + k \theta} + \frac{\gamma t}{a \theta}\right)} \qquad (19)$$

and in order to estimate the magnitude of the error arising from the terms involving t let us consider the values of the constants in the previous expression. In some of our instruments we find that the initial sag y_o is about 0·5 centimètre, and that $y - y_o$ is about 0·22 centimètre when ϕ is about 280°—that is, when the needle is deflected to the limit of the scale. Therefore, since

$$\phi_o = \frac{s}{r} y,$$

and

$$\phi = \frac{s}{r} (y - y_o),$$

it follows that

$$\phi = \frac{\phi_o}{2}, \text{ approximately,}$$

when the deflection has about its maximum value. Hence, if we write x for $\frac{\text{A V}^2}{1 + k \theta}$, x′ for $\frac{\text{A V}^2}{1 + k \theta}\left(1 - \frac{k t}{1 + k \theta} + \frac{\gamma t}{a \theta}\right)$, and ϕ' for the value of ϕ when x becomes x′, we have

$$\phi = -2 \phi + \sqrt{4 \phi^2 + \text{x}}, \text{ approximately,}$$

and $$\phi' = -2 \phi' + \sqrt{4 \phi'^2 + \text{x}'}, \quad "$$

therefore the proportional error when the deflection is a maximum

$$\frac{\phi - \phi'}{\phi} = \frac{\sqrt{\frac{\text{x}}{5}} - \sqrt{\frac{\text{x}'}{5}}}{\sqrt{\frac{\text{x}}{5}}}, \qquad \text{approximately,}$$

$$= 1 - \sqrt{1 - \frac{k t}{1 + k \theta} + \frac{\gamma t}{a \theta}}, \qquad "$$

Now k equals 0·00031 and a about 0·0000145 for platinum-silver; also θ is about 250° C. when the deflection ϕ is about 280°. Let t, the temperature through which the case of the instrument is raised above the temperature of graduation, be 50° C.: then, if γ be nought,

$$\frac{\phi - \phi'}{\phi} = 0{\cdot}007, \text{ approximately,}$$

that is, ϕ is diminished by about 0·7 per cent., in consequence of the increase of resistance of the stretched wire. And this temperature error can be made still less by giving γ a negative value—that is, by making the framework of the instrument have a larger coefficient of expansion than the stretched wire. For instance, if the framework which carries the stretched wire has a coefficient of expansion rather less than that of copper, the temperature error of the voltmeter in the higher parts of the scale will be practically nought.

The accuracy of the instrument depends, among other things, on the constancy of the elasticity of our magnifying springs. To test this we have had tests conducted regularly during the last two years on one of our magnifying spring ammeters. The current was measured absolutely on each occasion by the silver-deposit method, and, as this can be done more easily and accurately if the current be rather small, the ammeter selected for this series of tests was one that gave the maximum deflection (of about 270°) for 1½ ampères. Of course the only difference between this ammeter and a magnifying spring ammeter measuring a much larger current is in the gauge of wire used in the winding, and not at all in the spring; therefore any conclusions as to constancy that may be drawn from the results of the tests are equally applicable to any other magnifying spring ammeter. Sixty-four distinct tests have been made by different groups of students in the two years; and to impress on the students the importance of making such time tests of an ammeter, as well as to prevent their imagining that the silver-deposit test ought to give the same values for the currents as are indicated by the graduations of the scale of the ammeter, the students were warned that the ammeter had been intentionally graduated with an error—the error, in fact, being that the ammeter reads from 1½ to 2 per cent. too low.

Instead of giving the tests in the exact order in which they were taken, each group of tests is, for convenience of comparison, arranged in chronological order.

Tests made with a Magnifying Spring Ammeter initially graduated from 1¼ to 2 per cent. too low.

Date.	Temperature in degrees centigrade	Reading on ammeter.	Ampères by silver Voltameter.
6th October, 1885	...	0·588	0·592
19th July, 1886	21°	0·58	0·59
5th October, 1886	21°·8	0·58	0·596
October, „	17°·5	0·50	0·571
16th November, „	15°·8	0·5	0·514
6th October, 1885	...	0·65	0·682
14th October, „	...	0·65	0·666
10th March, 1886	13°	0·600	0·615
10th „ „	13°·8	0·64	0·657
10th „ „	14°	0·68	0·692
21st July „	22°·8	0·663	0·683
8th October „	17°·5	0·620	0·635
22nd „ „	17°·5	0·67	0·688
9th November, 1886 ...	13°	0·60	0·615
6th October, 1887	18°·4	0·60	0·618
3rd August, 1885	...	0·76	0·776
6th „ „	...	0·76	0·776
14th „ „	...	0·757	0·775
18th November, 1885 ...	12°	0·700	0·721
18th „ „ ...	...	0·721	0·744
9th December, „	8°	0·70	0·72
17th February, 1886... ...	14°	0·700	0·727
24th „ „	16°·1	0·720	0·746
23rd July, 1886	20°·5	0·722	0·749
6th October, 1887	18°·4	0·70	0·711
19th „ „	16°·5	0·70	0·716
25th October, 1886	15°·6	0·84	0·859
22nd February, 1887 ...	15°·6	0·80	0·820
5th October, „ ...	16°	0·80	0·821
5th „ „ ...	16°·5	0·80	0·828
16th „ „ ...	17°·25	0·80	0·813
1st November, „ ...	16°·6	0·80	0·814
1st „ „ ...	16°·6	0·84	0·861
15th February, 1887 ...	13°·5	0·90	0·916
1st March, 1887	12°·2	0·90	0·920
8th November, 1887 ...	18°·8	0·91	0·929
30th July, 1885	...	1·06	1·073
3rd December, 1885 ...	...	1·008	1·022
7th „ „	9°	1·07	1·096
9th „ „	7°·5	1·12	1·14
14th „ „	14°	1·12	1·14
27th October, 1886	14°·6	1·147	1·160

As the tests were made by a large number of different students, having very different aptitudes for such work, some of the results arrived at were obviously wrong, and have been rejected; but, excluding these few exceptional ones, the preceding are a fair sample of the results obtained, and we see that it is impossible to conclude from them whether the ammeter has become more or less sensitive during the two years. In other words, its sensibility for practical purposes has remained quite constant. The temperature was carefully recorded after the early part of 1886, since it was thought that perhaps some temperature error might become visible; but this has not turned out to be the case, so that *the temperature may be apparently neglected in using a magnifying spring ammeter.* With a magnifying spring voltmeter wound with copper wire there will, of course, still remain the error due to a variation of the resistance of the coil with temperature; but the important result that has been arrived at is that *the indications of a magnifying spring ammeter or voltmeter, when a given current is passing through it, is not altered by age or by the ordinary changes of temperature of a room.*

To further test this latter point a magnifying spring ammeter, adjusted so that the needle stood exactly at zero when the temperature was about 15° C., was placed in a bath and heated up to 40° C., for five hours; but no marked change in the zero could be observed, which would have been the case if the elasticity of the spring had sensibly varied, seeing that the weight of the soft iron cylinder was hanging at the end of the spring all the time. We feel, therefore, quite safe in using the magnifying springs for our new type of voltmeter.

We are now engaged in devising various means for compensating this new form of voltmeter for temperature errors; but before actually introducing these compensations into the instruments one of our students—Mr. Kilgour—has been carefully measuring the exact coefficient of expansion with temperature of fine platinum silver wire under a tension which is comparable with its breaking tension. The compensation for the short-tube form shown in figs. 3 and 4 will probably in part consist in the device adopted by Captain Cardew of making the support to which the wires are attached of a compound metal; while in the case of our bicycle-wheel form the rim to which the wires are attached will probably be made like the balance wheel of a chronometer; but, of course, the same accuracy of adjustment for temperature that is necessary in a chronometer will be quite unnecessary in the voltmeter, as the error is not a cumulative one as it is in a chronometer.

The following, we venture to think, are the improvements that we have been led to introduce into the Cardew voltmeter by employing the devices that we have described:—

1. A small alternating potential difference can be accurately measured, as the wire in our instrument may be short, and as the readings can be taken down to the zero with certainty.

2. With the same instrument a wide range of volts can be measured, since with many short wires combined with a commutator any number of them can be put in series; that is, any length of wire can be electrically used.

3. Whatever number of volts is being measured, all the wire is directly active in deflecting the pointer, which is not the case with an instrument provided with an external resistance for increasing the range.

4. The instrument is compact and portable.

5. Great dead-beatness of action is secured by the employment of much finer wire than has hitherto been commercially used, and by the magnifying gearing being frictionless and comparatively massless.

6. Non-liability of even such fine wire to break from a blow, in consequence of the frictionless and comparatively massless character of the magnifying gearing to which the wire is attached.

7. Diminution in the power wasted on the instrument by the employment of a short instead of a long wire.

At the same meeting the following paper was read:—

"On some Instruments for the Measurement of Electromotive Force and Electrical Power." By. J. A. Fleming, M.A., D.Sc. (Member), and C. H. Gimingham. These instruments do not present any novelty of principle. They differ from that form of instrument generally called an electro-dynamometer in the arrangement of details, but they depend for their operation upon the electro-dynamic action of currents in fixed and movable conductors. Our object has been to furnish an electro-dynamometer which shall be portable, compact, and require in its use no mercury cups, tables of square roots, nor multiplying factor, nor any reference other than to the scale of the instrument, in order that electromotive force and power may be determined by it at once. Our experience in the use and testing of voltmeters of nearly every kind has been such as to lead us to look doubtfully at any instrument which either contains soft iron, permanent or electro-magnets, or in any way depends for its action on the behaviour of iron when placed in varying or successively varied magnetic fields. No matter how treated, a piece of soft iron has a "magnetic memory." Unless rapid magnetic reversals, aided by rise of temperature, are brought to bear upon it, it is very difficult to eliminate from it the results of its previous magnetic history and to bring it back into the condition in which its magnetisation is the result, purely and simply, of the present magnetic force brought to bear on it.

We start, therefore, with the principle now adopted by Sir W. Thomson, that in thoroughly satisfactory electric-measuring instruments the magnetisation of iron must not be permitted to play any part in the design. In these instruments we submit to the criticism of the Society, the action is wholly based on the fact that, when conductors conveying electric currents are arranged so that one of them is fixed and the other free to move, the force required to hold the movable conductor in any given position in the field of the fixed conductor is proportional to the product of the strengths of the current flowing in these conductors respectively. The general design of the instrument is as follows:—There are two solenoids of insulated wire (German silver) wound on brass tubes. The solenoids are wound so as to have a magnetic pole in the centre of each, marked N, N. The ends of the solenoids are therefore similar poles, S. Two such solenoids are held in a frame, and fixed so as to be parallel to each other.

These fixed coils are embraced by two annular coils, which are wound on exceedingly light metal frames and are carried on the ends of an ivory bar. The resistance of the fixed coils may be about 1,000 to 1,500 ohms, and the resistance of the annular coils about 500 to 1,000 ohms. This ivory bar carries at its centre a glass-hard steel cup, by which it is supported, so as to move freely, like a compass needle, on a steel iridium-tipped needle. The coils are very accurately balanced, and, whilst embracing the fixed coils, have yet clearance enough to permit them to swing through a small angle on either side. Their range of movement is, however, limited by two stops.

To the ivory cross-bar carrying these movable coils is attached a steel spiral chronometer spring, the upper end of which is held in a tubular collar, capable of revolving stiffly in an aperture in the dial plate. This collar carries on the outside of it a mica-tipped index finger which is capable of being set round on the tubular collar and clamped in any position.

The inside of this tubular collar has an attachment by which the upper end of the steel spring can be taken up more or less, just as the hair-spring of a watch is set.

The current enters from one terminal, passes thence to the top of the spring, then down the spring into the movable coils, from there to the steel cup, through the contact-point to the iridium-tipped steel pivot, from that through the fixed coils, and so back to the other terminal. The windings of the movable coil are so arranged that it is astatic, and not influenced by a vertical or horizontal uniform field. This is important in an instrument to be used in the neighbourhood of powerful magnets.

The movable coils carry a light aluminium needle which projects up through a slit in the dial plate, opposite to the zero of the scale.

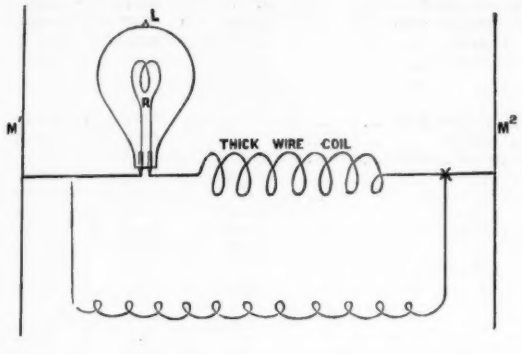
The whole instrument is contained in a small wooden box, about 4½ inches square by 3 inches deep. On opening the box a dial plate is seen having a circular scale divided so that the volt readings are obtained without any calculations. The operation of taking a reading is as follows:—The box is first levelled on the table by means of a wooden wedge provided for the purpose. The central hollow boss is first turned until the mica index finger is at the zero of the scale. The aluminium index, carried by the movable coils which project up through a slit in the dial, should also be opposite the zero. If this is not the case the mica index finger has to be shifted. This is accomplished by slacking up the milled head on the top of the central boss and re-adjusting the index until the mica index finger and the aluminium index of the movable coils both stand opposite to each other at the zero. The current is now passed, and the electro-magnetic action causes the movable annular coils to be shifted along the fixed coils, displacing the aluminium index. The central boss, carrying the upper end of the spring, is then turned until a torsional force is brought to bear on the movable coils, bringing them back against the electro-magnetic forces into the zero position. It will now be found that the upper end of the spring will have been twisted through a certain angle, as indicated by the position of the mica index finger. The value of the current passing through the instrument is proportional to the square root of this twist required to bring back the coils into their zero position, and, as the force brought to bear on the coils is proportional to the angular displacement of the upper end of the spring, it follows that the square root of the angular displacement of the mica index finger required to maintain the movable coils at their zero position is proportional to the strength of the current flowing through the instrument. To avoid any calculations or reference to square-root tables, the dial is graduated in the following manner:—If the instrument is intended to read, say from 20 to 110 volts, then one complete turn, or 360° displacement of the index, is required to balance the electro-magnetic force due to 110 volts on the terminals of the instrument. The angular displacement for x volts is, then, $\frac{360 \times x^2}{(110)^2} = \frac{18}{605} \times x^2$, measured in degrees, and accordingly the positions for all volt values from 20 to 110 can be set off directly on the dial. The index needle is then simply turned until the aluminium index is brought back to zero, and the dial reading gives at once the volts. This form of graduation has the advantage that the scale interval corresponding to one volt is greatest in that part of the scale which will be in each instrument presumably most used.

In order to render the instrument portable, means are provided to raise the movable coils off the point by the action of closing the box. A clutch-bar is so arranged and pivoted, that by means of a pin sliding in a hole in the box a pressure on the upper end of this pin raises the coils, and relieves the iridium point of the pressure of the movable coil-bar.

It is not desirable that the movable coils should be taken up and let down suddenly on the pivot, and to make this action deliberate the box lid is opened and closed by a screw. The user is thereby compelled to open the box slowly and let down the coils with a gentle motion on to the pivot.

The voltmeters are constructed to work over various ranges. One type ranges from 20 to 110 volts. By associating a resistance coil with the voltmeter, the resistance of which is equal to that of the voltmeter, the volt values of all the readings become doubled and the instrument becomes available for use between 40 and 220 volts. In order to give a little margin over and above the 110 and 220 volts, the graduation is continued, according to the square-root law, along an outer circle. A little more than one complete twist of the spring enables a reading to be taken up to 115 or 120 volts on the 110-volt instrument, or to 230 or 240 on the 220-volt instrument. In the 110-volt instrument the following are the electrical and mechanical data of the instrument:—The weight of the movable coils complete is in all 20·27 grammes. The number of turns of wire is 960, on both coils together, and the total resistance is 300 ohms. The four fixed coils have each 840 turns of wire, or 3,360 turns in all, and a resistance of 1,200 ohms. The total resistance of the voltmeter is therefore 1,500 ohms. The temperature resistance variation coefficient has been carefully determined for a mean temperature between 15° and 30° C. for the particular kind of German silver wire used, and it is ·0273 per cent. per degree. Accordingly, as far as regards change of temperature as a whole, it requires an alteration of 30° C. to make a change of 1 per cent. in the value of the voltmeter readings. To prevent, as far as possible, heating of the coils, each voltmeter is provided with a key. In using the instrument the first operation after opening should be to level it carefully, by inserting, if necessary, the wooden wedge provided under the front or back side until the pointer on the movable coils swings freely from side to side.

We have also constructed on this type a wattmeter. In this case the fixed coils (now called the current coils) are wound with thick wire, and so arranged that the four coils can be joined up in series or in parallel. From a separate pair of terminals the current is conducted into the thin wire coils, which are the movable coils, and constructed exactly as for the voltmeter, only with a higher resistance. In using this wattmeter for measuring the power taken up, say, in an incandescence lamp, the following method of joining up should be adopted:—



Let M_1, M_2, be the mains, and let L be the lamp. The lamp should, as usual, be put in series with the thick wire coils. The fine wire coils should have their terminals joined, not to the two terminals of the lamp, but to the terminals of the lamp and the thick wire coil as joined in series. The thin wire coil thus measures the potential at the extremities, not of the lamp, but of the lamp and thick wire coil in series. The reason for this is as follows:—Suppose the thick wire coil to have a resistance of ·01 ohm and the thin wire coil to have a resistance of 1,000 ohms, and apply this wattmeter to measure the power consumed in two lamps, each of 8 candle-power, and requiring, say, 20 watts—but in one case let the lamp be a 100-volt lamp taking ·2 ampère, and in the other a 10-volt lamp taking 2 ampères. If the fine wire coil is joined in parallel with the lamp alone, in the case of the high volt lamp, since the resistance is 500 ohms hot, the lamp will take two-thirds of the whole current flowing through the thick coil—in other words, the current which flows through the thick coil is not that flowing through the lamp, but that through the combined resistance of lamp and fine wire coil. If, however, the same wattmeter is applied to measure the power of the low volt lamp, then, since the hot resistance of this is only 5 ohms, the lamp will get $\frac{1000}{1005}$ths of the current flowing through the thick coil. It follows from this that whereas the two lamps consume exactly the same power, yet, in the first case, the current in the thick coils, which is that which actuates and is one of the factors in determining the reading of the wattmeter, is half as great again as it should be. It would be found that in the case of the high volt lamp the wattmeter reading would be 30 watts, and in the case of the low volt lamp 20 watts, although both lamps actually take the same power. If, however, the extremities of the voltmeter, or movable or fine wire coils, are joined, as shown in the figure above, then the current in the thick coil is exactly that through the lamp, the error in the electromotive force part of the measurement is then only dependent on the fact that the thick wire coil has an appreciable resistance; if this is only ·01 ohm, the error made in the electromotive force part of the measurement is only ·1 per cent., even in the case of the low volt lamp, by assuming the potential at the extremities of the lamp and thick coil in series as equal to that at the terminals of the lamp.

Unless the resistance of the current coils is vanishingly small compared with that of the high resistance or movable coils, the above method of joining up the wattmeter does not give the real rate of dissipation of energy in the lamp or other circuit under consideration.

Let us examine the theory of the instrument a little more closely. Let R (see following diagrams) represent the resistance of the thick wire or current coils, and let r represent the resistance of the fine wire or volt coils, and let ρ stand for the resistance of the lamp or other circuit in which the dissipation of energy is being measured. Given the ends of these thick and thin wire coils, we may then join them up to the lamp in either of two ways, as shown.

What we actually do in the use of a thick and thin wire electro-dynamometer, employed as a wattmeter, is to measure the product of the strengths of the currents in the thick and thin wire coils respectively, by measuring the electro-dynamic attraction between these circuits when held in certain fixed positions. If, however, the circuits are joined up to a lamp, as in the first case, although the current in R is equal to the current through the lamp, yet the current through r is not proportional to the difference of potentials on either side of the lamp, but greater by an amount which depends on the ratio of ρ to R. If W represents the true watts taken up in the lamp under measurement, and W_1 represents the observed watts by the dynamometer, on the assumption that it has been calibrated for one particular lamp of very high resistance compared with R, then

$$W_1 = W \frac{\rho + R}{\rho} \qquad (i.)$$

for w_1 is made up of two factors—one a number proportional to the current in R, which is the current through the lamp, and another factor which is proportional to the difference of potentials over all between the outside terminals of lamp and resistance R.

This last is greater than the potential difference on either side of the lamp, in the ratio of $R + \rho$ to ρ.

Next, let the fine wire coils be joined to the terminals of the lamp, as in the second case. The current in r is now proportional to the potential difference on either side of the lamp. The current in the thick wire coils is not, however, identical with that through the lamp, but equal to that through the lamp and fine wire coils together. If c stand for the current through the lamp, and C for the current in the thick wire coil R, then

$$c = \frac{r}{r + \rho} C,$$

and accordingly, if, as above, W stand for the true watts expended in the lamp, and W_2 for the watts as observed on the dynamometer, we have the relation

$$W_2 = W \frac{r + \rho}{r} \qquad \text{(ii.)}$$

From equations (i.) and (ii.) we have

$$W_1 \rho = W \rho + W \frac{R}{r} R,$$

$$W_2 r = W r + W \rho;$$

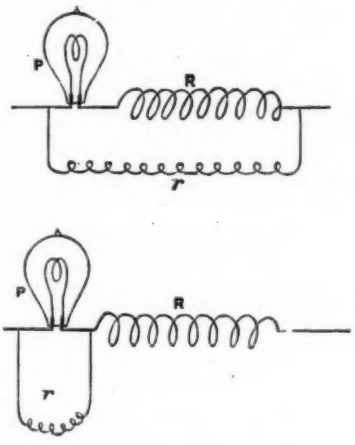
hence,

$$W^3 \frac{R}{r} = (W_2 - W)(W_1 - W);$$

or,

$$W^2 - \left(\frac{r}{r + R}\right)(W_2 + W_1) W + \left(\frac{r}{r + R}\right) W_1 W_2 = 0.$$

The solution of this quadratic equation gives W.



It is not difficult to show that this quadratic equation always has one real positive root, since r is greater than R, and W_1 and W_2 are positive quantities. We arrive, therefore, at this result:—If any given wattmeter of this type has been calibrated on a lamp or other circuit of which the resistance is very great compared with the thick wire or current coils, supposing the connections made as in the first case, then the observed readings of the wattmeter, when used with any other lamp or circuit, will not give the true watts expended in that circuit, but give a value which is rather too high, and of which the error will depend on the value of the three resistances, R, r, and ρ. We can, however, eliminate the error, and obtain a number proportional to the true rate of expenditure of energy in the circuit, ρ, by taking two observations with the high resistance coils joined up respectively, as in the two diagrams. If these readings are called W_1 and W_2, the insertion of these in the quadratic equation above will enable us to find a value, W, which is proportional to the real watts, and that without knowing the resistance of the lamp being tested.

In the construction of a wattmeter of this type it is evidently important that the current coils should have as low a resistance as it is possible to secure in comparison with that of the movable or voltmeter part. In our wattmeter the fine wire coils are of German silver wire, and have a resistance of 1,000 to 1,200 ohms. The thick wire or current coils are of the highest conductivity copper; and in the instrument designed as a lamp wattmeter, to read direct from 1 to 400 watts, have a resistance of about ·1 or ·2 ohm. It is intended to issue wattmeters of three grades—one reading from 1 to 400, the next from 10 to 4,000, and the highest from 100 to 40,000, and suitable for electromotive forces of 50 to 250 volts.

In the wattmeter above described the scale is, of course, a scale of equal divisions. In the form of instrument adapted for lamp measurements, the circular scale is divided into 400 divisions, and each division represents 1 watt. By means of a wattmeter and voltmeter of the above description, all the four electric elements of a lamp can be measured at once. We have designed an instrument which shall be a combination of watt and voltmeter, and enable the two measurements of potential difference at extremities of a circuit and power consumed in that circuit to be simultaneously measured, and therefore to give at once the current in the circuit and the hot resistance. In this instrument the fixed coils would be wound compound, with two coils on each, one thick overlaid by a thin wire winding.

The connections of the fine wire windings on the fixed coils are so arranged in conjunction with a switch, that when the switch is turned one way the solenoids have, as ordinarily arranged, a N pole at the centre of each, but when the switch is turned the other way this pole is abolished. Hence, if a current flows through these fine wire windings in series with the movable coils, then according as the switch is set one way or the other, the current will operate the instrument or not, and that without changing its resistance or affecting the current in the movable coils. Let then the thick wire coils be traversed by a main current, and the thin wire coils by a current derived by connecting their extremities to the ends of the conductor traversed by the current through the thick wire coils. The electro-magnetic force operating to displace the movable part of the instrument will be the resultant of two forces—one due to the product of the strength of the current in the thick coil and the current in the movable coil. This product is proportional to the power consumed in the conductor. Secondly, in addition, there is a force due to the action of the current in the fixed fine wire coils on the current in the movable coils in series with them. This force is proportional to the square of the current strength or to the square of the volts at the ends of the conductor. Hence, if the switch is turned so that both thick and thin wire-fixed coils are operative, the electro-magnetic force on the movable coils is proportional to the watts added to the square of the terminal volts. If W be the power consumed in the conductor, and V the potential difference at its extremities, then this reading of the instrument will be proportional to $A W + B V^2$, when A and B are instrumental constants. Next, let the switch be turned so as to render the fine wire coils electro-magnetically inoperative, although not altering the resistance of the total fine wire circuit. In this case the reading off is simply proportional to the power consumed in the conductor, or to A W. We have therefore, by two readings, the power consumed and the terminal volts of the conductor or circuit, and hence, by simple division, the current and hot resistance.

In this method of measuring a current, the movable part of the instrument is not traversed by any but a very small current, and hence the difficulty generally experienced in getting a large current in and out of a freely-moving circuit has not to be combated. In considering these instruments as permanent standards, the question obviously arises as to the permanence and perfect elasticity of the steel spring. The steel chronometer spring is made of the very best and most carefully-tempered steel. The use in chronometers justifies the statement that, when not strained beyond the limits of elasticity, and when not kept in strain for a longer time than necessary to take a reading, the elasticity is perfect. There is only one caution which should be taken in using these instruments. After taking a reading, the central index-hand should be turned back to zero before putting the instrument away. If the voltmeter is closed up and put on one side, with a permanent twist upon the spring, then a slight deformation of the spring may result, which will in time disappear, but not immediately. The elastic modulus which is brought into play in this use of a spiral spring is somewhat similar to that which is operative when a beam is bent. The spiral is not drawn out, but is twisted round and bent slightly into a smaller radius. Under prolonged strain a very slight deformation occurs, which disappears gradually on the removal of the stress, and this deformation is a function both of the stress or strain and the time under which the elastic body is submitted to that stress.

On this point we may quote the experience of Professor W. Kohlrausch, who, in a paper in the *Electrotechnische Zeitschrift*, gives the result of prolonged experiments on the employment of spiral springs in measuring instruments. The effect of age, judging by observations on a brass spring extending over a period of seven years, may be completely neglected. Continuous and prolonged deformation produces a small amount of permanent set, so that the spring, when released, does not return to its original position, but this does not actually alter the indications of the instrument if the readings are taken from the new zero thus formed. Steel is in this case less affected than German silver. Oft repeated but intermittent deformation, as exhibited by a spring of 90 convolutions and 2½ inches long being stretched, so as to change from a length of 3 inches to 9 inches 200 times per minute for 400 minutes, introduced no sensible alteration into its subsequent indications.

An increase of temperature of 18° Fahr. raised the indications of a Siemens torsion galvanometer about $\frac{1}{10}$th per cent., so that the reduction in elasticity of the spring is apparently almost equal to the decrease in moment in the magnet. Further experiments on loaded springs confirmed this conclusion, and showed that steel was again to be preferred to German silver. We think, therefore, that there is sufficient evidence to lead us to believe that the selection of a highly-tempered steel chronometer spring as a means of weighing the electro-dynamic attraction of coils traversed by currents will not be found to lead to appreciable errors.

Instruments with the suspension we have here designed and used are not very well suited for marine use, but we are engaged in arranging a mode of supending the movable coil which will render the instruments independent of any levelling when in actual use.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1886.

15774. "Improvements in electrical switches and appliances connected therewith." I. PROBERT. Dated December 2. 1s. 3d. Relates to improvements upon the apparatus described in patent specification 2,691 of the year 1886 and comprises modifications which widen its range of usefulness in certain applications of electricity. The claims are 11 in number.

1887.

3346. "Improvements in the arrangements for lighting railway vehicles electrically." I. A. TIMMIS. Dated March 4. 11d. The objects of the invention are to provide an arrangement for electrically lighting railway vehicles, which shall be simple, not liable to get out of order or fail in action, and be economical in first cost and maintenance. The claims are 6 in number.

4027. "Improvements in and connected with the measuring of alternating or intermittent electromotive force." R. DICK and R. KENNEDY. Dated March 17. 4d. Claims:—1. In a system of distribution of electric energy the combination of an alternating or intermittent current transformer with a voltmeter or potentiometer, for the purpose of measuring the electromotive forces or potentials of alternating or intermittent electric currents, substantially as set forth. 2. The combination of a transformer of alternating currents with a voltmeter or instrument for measuring electric potentials for the purpose of accurate measurement of electromotive forces or potentials which are too small or too great in magnitude for measurement by ordinary voltmeters or potentiometers. 3. In a system of distribution of electric energy the combination of a transformer of alternating or intermittent currents having one or both of its electric circuits subdivided to obtain higher or lower ratios between the circuits, with a voltmeter or potentiometer for the purpose of measuring alternating or intermittent electromotive forces or potentials, substantially as set forth.

4109. "Improvements in electrical burglar alarms." R. HADDAN. (Communicated from abroad by G. Schleicher, of America.) Dated March 18. 8d. This invention relates to electrical burglar alarms, and has for its object the protection of a structure or window to be guarded by means of a curtain or fabric, to which the mechanism for actuating the alarm is connected. The claims are 9 in number.

4571. "Improvements in the the construction and manufacture of zincs for galvanic batteries." W. E. HEYS. (Communicated from abroad by J. Beattie of America.) Dated March 28. 4d. Claims:—1. The process of making amalgamated zincs for galvanic batteries which consists in melting a quantity of zinc and adding thereto an amalgam of any metal except zinc, substantially as described. 2. The process of making amalgamated zincs for galvanic batteries which consists in uniting mercury and another metal other than zinc by heat, adding arsenic and carbonate of sodium, allowing the mass to cool, and afterwards dissolving it in molten zinc, whereby an amalgam is first formed, and afterwards an amalgam combined with the zinc, substantially as set forth.

4664. "Improvements in or relating to electric furnaces applicable for making aluminium and for other purposes." W. P. THOMPSON. (Communicated from abroad by E. H. Cowles and A. H. Cowles, both of America.) Dated March 29. 8d. Consists in the means by which the varying electrical resistance of the charge in the furnace is made the primary agency in actuating and controlling the feeding of the material to be smelted or reduced. Also consists in the means of automatically regulating and controlling the charging, feeding, and discharging of a furnace of the type hereinafter described through the agency of the electrical resistance of the charge in the said furnace. Also consists in the construction of the furnace, and in the combination therewith of the feeding, discharging and resistance regulating apparatus as hereinafter fully described and claimed; whereby the varying electrical resistance of the charge in the furnace is made the primary agency in actuating and controlling the feeding of the material to be smelted, and discharging the products. The claims are 10 in number.

4667. "Improvements in galvanic battery solutions." W. P. KOOKOGEY. Dated March 29. 4d. Claim:—The described method of producing a battery solution, which consists in dissolving bichromate of potash or bichromate of lime in hot water, adding to the mixture sulphuric acid, then permitting the preparation to cool and stand, during which time the sulphate salt is crystallised and precipitated, then decanting the liquid from the precipitate, the materials being combined in substantially the proportions stated.

4744. "Improvements in means for supporting or suspending elements in electric batteries." H. I. HARRIS. Dated March 30. 6d. Claims:—1. In electric batteries the means for supporting the zinc or other elements consisting of a hook or its equivalent engaging with the element at or about the centre thereof, substantially as and for the purpose described and illustrated 2. In electric batteries the means for supporting the zinc elements consisting of a hook of copper engaging with the zinc element so as to support it at or about its centre, substantially as and for the purpose described and illustrated. 3. In electric batteries the combination of a hook and plate perforated at or about its centre to engage with the said hook, and an insulating cover all arranged and combined, substantially as and for the purpose described and illustrated. 4. In electric batteries of the kind described in the specification of patent 8,228 of 1885 the combination of means for supporting the zinc elements thereof, substantially as described and illustrated. 5. In electric batteries supporting or suspending the zinc or other elements at or about their central portion as and for the purpose described.

4931. "An improved construction of battery and method of regulating the same." M. BAILEY and J. WARNER. Dated April 2. 8d. Claims:—1. The improved combination and arrangement of battery, fitted with moving platform, carrying the elements, the same being actuated by a regulating hand wheel and screw, or equivalent rack and pinion, or worm, worm wheel, pinion and rack, or by counter balance. A drawer divided in compartments, for holding the jars, bottles, or cells, the whole combined and operating together as described and for the purposes set forth. 2. In combination with a battery fitted with a movable platform supporting the elements, the method of suspending the carbon or equivalent element to said platform by means of lead, copper, or other metal strip, the zinc or equivalent element being suspended by means of a wood, or other block of insulating material within it, as set forth. 3. The combination in or with a regulating battery arranged as described, of the porous pot or diaphragm, so placed as to be surrounded by the suspended carbon or equivalent element, for the purpose of permitting a double fluid to be used in the cell, substantially as set forth.

5025. "An improvement in electric cables and insulating and protecting the same." T. H. DUNHAM. Dated April 5. 6d. Claims:—1. In an electric cable the combination of the core of the electric wires thereof with untwisted raw cotton or raw silk, said cotton or silk being saturated with a solution of resin, pitch and tar, substantially in the manner and for the purpose described. 2. In an electric cable, the covering and protecting the core of electric wires thereof by one or more iron wires covered with untwisted raw cotton or raw silk saturated with a solution of resin, pitch and tar and twisted around the core, substantially in the manner described and for the purpose set forth. 3. An electric cable with each of the electric wires thereof covered with untwisted raw cotton or raw silk; the entire core of said wires being covered with said raw cotton or raw silk saturated with a solution of resin, pitch and tar, and the whole core covered and protected by a shield composed of one or more iron wires covered with said raw cotton or silk saturated with said solution of resin, pitch and tar, and twisted around said core, substantially in the manner described and for the purpose set forth.

5309. "A certain system of laying, supporting, and repairing electric conducting wires and cables, and other electric conductors." H. FLAD. Dated April 12. 11d. Consists in supporting the electric wires and cables at short distances apart on cross-beams, frames and brackets, which are fastened to two or more suspension cables of sufficient strength to carry the load arising from the cross-beams, cables, brackets, wires and other fixtures, and also of the car, which is used in laying, repairing, and removing the supported cables and wires. Such suspension cables are to be attached to towers, which are preferably of such height that the lowest parts of the cables are above the highest windows of the houses along the line, and so located in a plane passing through the centre of the street, as to prevent them from being interfered with by occupants of the houses, and to secure them from injury by fires. The towers are preferably erected at the intersections of streets, or at such other points as are best adapted for the efficiency of arc lights, in case such lights are to be used for lighting the streets. There are 23 claims.

5533. "Improvements in vibrating electric motors." A. L. PARCELLE. Dated April 15. 11d. Has special reference to the class of motor shown in United States letters patent, No. 324,152, granted to the inventor August 11th, 1885. The claims are 11 in number.

5534. "Improvements in electrical synchronous movements." A. L. PARCELLE. Dated April 15. 8d. Relates to synchronous movements of the class shown in the United States letters patent, No. 324,153, granted to the inventor August 11th, 1885, and covers certain improvements on the mechanism and arrangement shown in the said patent. The claims are 12 in number.

5687. "Improvements in fusible connections for armatures for electric generators." W. P. THOMPSON. (Communicated from abroad by H. W. Spang, of America.) Dated April 19. 6d. Claims:—1. The combination with the armature of a dynamo-electric generator of a fusible connection between the junctures of the armature coils and the commutator plates, substantially as described. 2. The combination with the armature coils of an electric generator of contact plates and fusible metallic conductors, connecting the junctures of said bobbins with said plates. 3. The combination in an electric generator with a series of commutator plates and a series of bobbins of a fusible metallic strip between each juncture of each bobbin and each contact plate, and means for replacing any of the said fusible strips, substantially as described.

5704. "Improvements in arrangements for binding electrical cut-out fuses or other suitable articles." G. C. SILLAR. Dated April 19. 6d. Claim:—A screw, nut, or other suitable binding apparatus, so constructed that there shall be interposed between the binder and the thing bound a suitable spring or springs, which shall compensate for any alteration in the distance between them, substantially as described.

6160. "Improvements in electric inductive translators or transformers and in means for regulating them." W. MAIN. Dated April 27. 1s. 3d. Relates to apparatus for translating or converting high tension currents on one circuit into low tension currents on another, or *vice versâ*. The claims are 26 in number.

6604. "A combined battery and circuit closer." M. BAILEY and J. WARNER. Dated May 5. 6d. Claims:—1. A combined battery and circuit closer consisting of any known elements, the zinc or equivalent element being lifted out of the exciting fluid by the closing door, window, flap, or other device to which it is attached, substantially as described. 2. The combination with a battery and circuit closer constructed as described, of the cruciform lug, pulley, and adjusting nut fitted with metal wire, said lug acting as one terminal of the battery employed, as set forth. 3. The combination with a battery and circuit closer as described, of the insulated bell crank and counterbalance or check spring, substantially as described. 4. The application and use with a combined battery and circuit closer, of the existing form of ordinary bell crank and check spring, for the purpose of raising and lowering the zinc or equivalent element into or out of the exciting fluid, as set forth.

6745. "Novel electrical apparatus for use in checking instructions on board ships." H. P. SHERLOCK. Dated May 7. 6d. Has for its object to instantly announce to the officer or person in charge of a steamship when an order, transmitted by means of the ordinary ships' telegraph to the engine room has been mistaken or wrongly interpreted by the engineer, and thus provide a means of ensuring that, in every case, the direction of motion of the engines shall coincide with the actual order given by the person in charge of the vessel. There is 1 claim.

6828. "Improvements in the regulation of dynamo-electric machines. E. T. HIGHAM and D. HIGHAM. Dated May 10. 8d. Claims:—1. The combination of the dynamo shaft and engine shaft, with a spring connection between the two, and devices controlling the supply of motive fluid to the engine, with a compensator for the springs, substantially as and for the purpose set forth. 2. The combination of the dynamo-electric machine and driving shaft, with a lever fast to the shaft, a wheel loose from the shaft, and springs connected at one end to the wheel, and having at the other end a connection with the lever, varying the leverage of the latter in proportion to the varying tension of the springs, substantially as set forth. 3. The combination of a dynamo-electric machine and driving shaft, with a lever fast to the shaft, a wheel loose from the shaft, an eccentric controlled by the wheel and lever to operate the valve of the motive power engine, and springs connected at one end to the wheel, and having at the other end a connection with the lever, varying the leverage of the latter in proportion to the varying tension of the springs, substantially as set forth. 4. The combination of a dynamo-electric machine and driving shaft, with the wheel loose on the shaft, a lever fast thereto and having inclined bearing faces, with an eccentric operated by the wheel to control the engine valve, and springs connected to the wheel and having a strap connection with the inclined faces of the lever, all substantially as specified.

6829. "Improvements in electric batteries." P. JENSEN. (Communicated from abroad by Dr. Orazio Lugo, of New York.) Dated May 10. 4d. Claims:—1. An electric battery in which one element is in contact with an acid and the other with an alkaline solution, one liquid containing a substance which will retard or nearly prevent inter-diffusion of the liquids, substantially as described. 2. An electric battery in which the positive element is in contact with an alkaline solution and the negative element with an acid solution, there being an interposed porous medium between the solutions, and the acid solution containing a metallic salt, whereby, while the acid acts to keep the negative element free from deposit of objectionable elemental matter, thus obtaining a constant electrical energy or volt-ampère, the salt will prevent or retard the inter-diffusion of the solutions, without preventing, when the circuit of the battery is closed, osmotic action of gas through the porous medium, substantially as described. 3. The method of decreasing or increasing the ampère current by changing the relative proportions of the acid and metallic salt around the negative electrode, substantially as described.

6844. "Improvements in electric arc lamps." A. J. BOULT. (Communicated from abroad by C. M. Noble, of America.) Dated May 10. 8d. Has relation to electric arc lamps and more especially to that class of arc lamps in which carbons of equal length are used and so arranged as to converge from their point of support to their tips, and said invention consists in the improved construction and combination of parts constituting such a lamp, as will be hereinafter fully set forth. The disadvantages arising in such a system are overcome by so pivoting the carbon holders that the tips of the carbons shall swing instead of sliding to the point of convergence. To regulate this swinging so that the said tips shall meet in the proper manner weights are attached to the carbon holders which tend to keep said tips together, and at the same time said holders are linked to a rod controlled by an electro-magnet, in a manner such that the portion of the current of the lamp which passes through the said magnet shall counteract the tendency of the weights sufficiently to keep the tips of the carbons at the proper distance to produce the desired arc. An automatic switch is also constructed which shall operate to cut the lamp out of the circuit when the carbons have burned to such a point as to allow a prolongation of one of the carbon holders to trip a lever controlling the contact points of the said switch. The claims are 5 in number.

CORRESPONDENCE.

Measurement of Alternating Currents.

I am sorry Mr. Swinburne does not understand the drift of my former letter. What I meant is that a wattmeter, whether accurate, like the one he has in his mind's eye, or distinctly the reverse, is of no use in the practical running of an installation, while a voltmeter is of vital importance. I readily grant that for the special purpose of testing transformers a wattmeter of the first species would be useful.

Mr. Swinburne's article in your issue of the 30th ult. gives the information I asked for as to his views on the great "twinkling" or "flickering" question (I prefer "twinkling;" flickering essentially involves the idea of unsteadiness and arc lamps).

To get an idea of what the twinkling can amount to, I have roughly calculated the following simple case:—Take a filament 7 inches long, ·005 inches diameter, giving 15 candles at 100 volts, and taking 45 watts direct current. (These figures are, I believe, about right.) Suppose it supplied with an alternating current making only 100 alternations per second, and for simplicity consider that it receives 90 watts for $\frac{1}{200}$th second, and then 0 for $\frac{1}{200}$th second. Taking the specific gravity of the carbon to be 1·6 and its specific heat ·2, I find the total variation of temperature would be about 60° C. This is, of course, far greater than is actually the case. In the first place, the alternations are generally at least 200 per second. Secondly, the maxima and minima values of the power are only instantaneous, and for the greater part of the time the power is nearer the mean. Thirdly, the specific heat at the temperature of the lamp will much exceed ·2.

Probably a total variation of 10° C. is all that is practically experienced. With a Cardew voltmeter taking 30 watts mean, first 60 then 0, the total variation of temperature comes out about 4° C., or under practical conditions perhaps 1° C.

The variation of resistance of the filament for temperature is, I understand, positive and very small at the temperature considered, while that of the platinum silver wire in my voltmeter is well known.

P. Cardew.

Chatham, *January 13th*, 1888.

A Parallel to Curative Electricity.

About three years ago, while in the Soudan, I purchased from an Arab a couple of amulets which were said to contain precepts from the Koran, no doubt written by some man of great piety, and to be sure preventives or cures of all the ills to which human flesh is heir.

Not having made any practical test of their efficacy I cannot speak to their healing qualities, but feel that they would not compare unfavourably with those of electropathic belts.

Vulgar curiosity tempted me a few days ago to investigate the component parts of one of these sacred charms. On ripping open the well-stitched leather covering I found, not the precepts of the prophet, but apparently some remnants of the tail of his shirt, wrapped round a fragment of wood. Observing their extreme age, and the great use to which they had at some period been put, my feeling of reverence prompted me to dispose of the holy relic by the process of cremation, a course I would respectfully suggest to the owners of electropathic belts.

Charles F. C. Beresford, *Major R.E.*

Novel Form of Arc Lamp.

I notice a letter from Mr. W. Hamilton in the last number of the ELECTRICAL REVIEW, referring to a patent of his, No. 6,221, 1887, in which he claims the application of electrolysed gases to the regulation of arc lamps. This appears to be an instance of the neglect so general among inventors in not properly searching the records of the Patent Office before patent-

ing their ideas. I remember some time ago having made a special note of a specification relating to this method of regulating lamps.

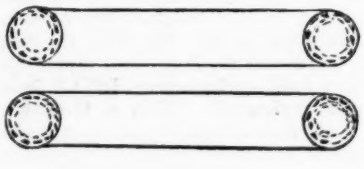
On referring I find it to be No. 9,325 for 1885, in which is described the application of electrolysed gases in several ways to the regulation of arc lamps. If Mr. Hamilton had taken the pains to find and read this specification he might have saved himself considerable trouble, as it appears that he has no more claim to priority than has Mr. Ulke.

A. Blanchard.

January 16*th*, 1888.

Sir William Thomson's Current Balance for Alternate Currents.

Referring to Mr. Swinburne's communication in your last issue, his fig. 4 (reproduced here) shows precisely what I understood him as meaning by "the error from the wire itself." The mutual force between the two coils, with currents distributed through them as here indicated, is approximately the same as it would be if the whole current flowing through each coil at any instant were condensed in the circular axis of the coil; and still more nearly the same as it would be if the current were uniform throughout the cross section. The degree of approximation to which this statement is true depends upon the smallness of the diameter of the cross section in comparison with the diameter of the circular axis. It would be rigorously true if,



instead of two circular coils, we were dealing with two parallel straight cables. There can be no doubt that it is a good practical approximation to the truth in respect to the cable coils of my electric balance as made for the measurement of alternate currents. It is because it is so that the *mutual* induction of the coils is prevented by the cable formation from producing in the distribution of currents any deviation from uniformity from centre to circumference of the cross section, such, for example, as that represented in the diagram here reproduced. Thus is verified the first of the two sentences of Mr. Swinburne's, quoted in my former letter.

William Thomson.

The University, Glasgow,
January 16*th*, 1888.

Curative Electricity.

We have noticed in your paper of late several communications which are evidently inspired by a person who was in our employment for a few weeks, and who writes these effusions out of pure pique and spite. We are somewhat surprised that a respectable scientific journal should open its columns to such abuse, which, considering the status we hold, both with the public and the profession, is not calculated to do us the least harm.

The signed letter in your issue of the 13th inst. is a pure fabrication from beginning to end, but we do not intend to give this individual a cheap notoriety by an action at law, in which we should undoubtedly be successful, but should nevertheless be unable to recover even our costs.

The best answer to the scientific sneers of a late servant is the enclosed copy of his own letter to the company, which refutes him out of his own mouth, and we must ask you to give the same publicity to this letter and enclosure as the thinly-veiled attacks upon us have obtained, and in the event of their repetition we shall hold you responsible as the disseminator of a scandalous and defamatory libel.

The Medical Battery Company, Limited.
C. B. HARNESS, *Managing Director.*

January 17*th*, 1888.

[COPY OF LETTER SENT TO THE COMPANY.]

"244, The Grove, Hammersmith,
"December 8th, 1886.

"Dear Sir,—Before leaving your establishment this afternoon I asked your manager to lend me one of the belts in order that I might test it for a current.

"Mr. Carpenter declared that it was impossible to get a current from the ordinary disc belt, but I can obtain 350° deflection through 105,210 ohms resistance from any pair of discs on the belt that was handed to me by your manager this evening.

"This I will prove to you by ocular demonstration on Saturday morning.

"The chemical action is as follows, taking chloride of sodium as the principal constituent of sweat:—

"$Zn + 2\,Na\,Cl + H_2O + Cu = Zn\,Cl_2 + Na_2O + H_2 + Cu$.

"I am, Dear Sir, yours faithfully,
"W. LYND.

"C. B. Harness, Esq."

[So far as we are aware the names of Mr. C. B. Harness and the Medical Battery Company, Limited, have not been mentioned in this controversy, but it is very evident that the cap fits. As to the last paragraph, we beg to assure our correspondent that we will not trouble him to hold us responsible for anything, as we invariably bear our own responsibility. We do not see that the copy of Mr. Lynd's letter places any better construction on the matter, for everybody knows that a current of electricity can be obtained from a copper-zinc couple when properly used, but doubtless that gentleman can give a satisfactory explanation of the circumstances which led to the correspondence in question.—EDS. ELEC. REV.]

A New Departure in Brazing and Welding.

The cheapening of oxygen by Brin's process of manufacture has put into the hands of metal workers a new power. I have recently made a few experiments with the compressed oxygen and coal gas, and found that with a half-inch gas supply a joint could be brazed in a two-inch wrought iron pipe in about one minute, the heat being very short, the redness not extending over one inch on each side of the joint.

The appearance of the surface after brazing led me to experiment further with welding, a process which is not possible with ordinary coal gas and air, owing to the formation of magnetic oxide on the surfaces Contrary to my expectation, a good weld was obtained on an iron wire one-eighth inch diameter, with a very small blowpipe, having an air jet about $\frac{1}{32}$inch diameter. This matter requires to be taken up and tried on a large scale for such work as welding boiler plates, which, it appears to me, can be done perfectly with far less trouble than would be required to braze an ordinary joint. The great advantage of this would be that the boilers would require no handling, but could be welded with an ordinary large blowpipe in position, and with about one-tenth the labour at present necessary.

The cost of the oxygen is trifling, and it is evident from the results obtained in brazing that the consumption of gas would be considerably less than one-fourth that necessary with an air blast, irrespective of the fact that welding is possible with an oxygen blast, whereas it is not possible if air is used.

The surface of iron heated to welding heat by this means comes out singularly clean and free from scale, and a small bottle of compressed oxygen with a blowpipe and a moderate gas supply, would make the repairs of machinery, boilers, brewing coppers, and other unwieldy apparatus a very simple matter. The trouble and difficulty of making good boiler crowns, which so frequently "come down," would be very small indeed, when the workman has an unlimited source of heat at command, under perfect and instant control.

Thos. Fletcher.

17*th January*, 1888.